THE UNIVERSITY OF ALBERTA

LIME-ASPHALT STABILIZATION OF A HIGHLY PLASTIC CLAY

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ABSTRACT

Stabilization of less stable materials with the use of various admixtures has begun to play an important part in highway construction.

In this study an highly plastic clay was stabilized with the combined use of asphalt and lime. The clay was pretreated with lime prior the addition of asphalt.

The test program investigated the strength of these mixtures after 7 and 28 days curing at room temperature, and 1 day of soaking.

The loss in strength of the compacted samples and resistance to water for immersion periods of 7 and 14 days were also determined.

The unconfined compressive strength of 2-in. by 4-in. specimens was performed by using the Tinius Olsen hydraulic testing machine.

It was found that pretreating periods were detrimental in terms of strength, density and swell, but were beneficial to the break down of clay clods which facilated the final mixing.

It was also found that water resistant properties were improved and strengths were reduced by gradually increasing asphalt content.

RESUME

La stabilisation des matériaux moins permanents avec l'emploi de diverses additions a commencé à jouer un rôle important dans la construction de nos routes.

Dans cette étude, une argile très plastique était stabilisée avec l'emploi combiné de l'asphalte et de la chaux. L'argile était antérieurement traitée avec la chaux avant l'addition de l'asphalte.

Le programme d'essai recherchait la résistance de ces mélanges après des périodes de curage de 7 et 28 jours à la température de la chambre, et 1 jour de trempage.

Les pertes de solidité des échantillons compactés, et de résistance à l'eau, pour des périodes d'immersion de 7 et 14 jours étaient aussi déterminées.

La résistance à la compression sans contrainte latérale des spécimens de 2-po. par 4-po. était accomplie en utilisant la machine d'essai Tinius Olsen.

Il fut trouvé que les périodes de traitement étaient nuisibles en ce qui concernaient la résistance, le poids volumétrique, et l'augmentation en volume, mais étaient avantageuses pour briser les mottes argileuses, ce qui facilitaient le dernier mélange.

Il fut aussi trouvé que les propriétés de résistance à l'eau étaient améliorées et la force des spécimens était diminuée par l'augmentation graduelle de la quantité d'asphalte.

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CHAPTER I

INTRODUCTION

Since the beginning of modern road construction, highway engineers have strived continously to produce better pavements at lower costs. Improvements of locally available materials by the addition of binders is one very promising approach to the problem of increasing shortages of high quality soils and aggregates. Puzinauskas and Kallas (1961)[1] in discussing this method have subdivided possible binder materials into three general groups:

The first group comprises cementing materials which may include portland cements, limes and acidic phosporus compounds.

The second group represents materials which may be added to the soil in order to modify it. Modifiers which are often used include limes, calcium or sodium chlorides, and a number of surface active materials.

The third group embraces the waterproofing agents. Typical representatives of this group are asphalts, certain resinous materials and coal tars.

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[1]References are cited by indicating the author and the year of publication. The references are contained in the bibliography at the conclusion of this thesis.

Asphalt has been used in soil stabilization largely because of its waterproofing characteristics. When the asphalt is mixed with the soil, it forms a very thin waterproofing film around the individual soil grains or around groups of soil grains, thereby hindering the penetration of water into the stabilized soil mass.

In the recent years, there has been a growing interest in the use of lime for stabilizing soils. It is relatively inexpensive and can often be used to produce both a chemical change and a cementing action that will improve the soil. Research and field experience have shown that lime treatments of clayey soils produce beneficial property changes. Lime assists in pulverizing the highly cohesive clays, thereby increasing their workability.

I. 1 THE PURPOSE OF THIS INVESTIGATION

This thesis was part of a continuing project of the Co-operative Highway Research Program of Alberta studying the chemical stabilization of soil.

This particular study deals with lime-asphalt stabilization of a highly plastic clay soil. The purpose of the lime was to assist in pulverizing the highly plastic clay, which could then be made more water resistant by the addition of asphalt. Since the effectiveness of these assumed actions was not known, the principal questions to be investigated were:

1. Is the pretreatment with lime effective in reducing the plasticity of the highly plastic clay, thus making the clay more "workable"?

2. Is the addition of asphalt beneficial as a secondary additive in the stabilization of highly plastic clay modified with lime?

I.2 OUTLINE OF THESIS

Chapter two is a review of the literature pertaining to lime stabilization of clays. A brief commentary of the role of asphalt in stabilization is also presented.

Chapter three describes the constituents employed in this investigation, followed by the scope of the testing program and procedures used.

Chapter four contains results and comments on the testing program and on the significance of the tests.

Chapter five is reserved for the conclusions and recommendations arising from this investigation.

The appendices contain data sheets, classification tests, moisture-density-strength relationships on the pretreated clay. A special study concerning lime-pozzolan stabilization of a medium-fine sand and of a highly plastic clay is also included. This particular investigation involved the use of several types of pozzolans, including Drumheller and Forestburg flyashes and processed Diamond City Shale.

CHAPTER II

REVIEW OF THE LITERATURE PERTAINING TO LIME AND ASPHALT STABILIZATION OF CLAYS.

Literature reviews dealing with clay-lime mixtures have been made by Watt (1961) and Hvozdanski (1962), therefore, in the following paragraphs only the more important properties and a review of subsequent publications will be related.

II. 1 MECHANICS OF LIME STABILIZATION

When lime is mixed with a moist soil, several types of chemical reactions occur. The most important of these reactions for stabilization seem to fall into three general categories that are (1) ion exchange and flocculation, (2) cementing action, (3) carbonation.

Ion Exchange and Flocculation

When lime is added to a moist cohesive soil and allowed to cure in a loose condition for a period of time the soil becomes more friable. Herrin and Mitchell (1961) described this phenomenon as being due to one of the following two conditions or possibly to a combination of them. In one, a base-exchange reaction takes place with the strong calcium cations of the lime replacing the weaker metallic ions, such as sodium and hydrogen, on the surface of the clay particle. The second process is the crowding of additional calcium cations of the

lime near the surface of the clay. These processes change the number of electrical charges on the surface of the clay particle. Because the bond between two clay particles is dependent upon the charge and the size of the ions, the preponderance of the divalent calcium ions that have replaced the univalent ions attract the soil particles together. As this reactions takes place the soil becomes more friable and the plasticity is lowered.

Cementing Action

The calcium in the lime reacts with certain soil minerals to form new compounds which produce a cementing action between the soil particles. These minerals in the soil that react with lime are known as pozzolans. The type and amount of pozzolans and thus the amount of reactivity with the lime vary from soil to soil. Usually this lime-cementing action in soil is a slow reaction.

Carbonation

This third reaction occurs when the lime absorbs the carbon dioxide from the air. The carbon dioxide reacts with calcium hydroxide in the lime to form calcium carbonate. These carbonates form weak cements and deter pozzolanic action and prevent normal strength gains.

II.2 INFLUENCE OF TIME BETWEEN MIXING AND COMPACTION ON PROPERTIES OF A LIME-STABILIZED CLAY

Effect on Density

Mitchell and Hooper (1961) reported that a stabilized clay-lime mixture decreased in density with increased time intervals between mixing and compaction when the same compactive effort was used for the preparation of the specimens. They suggested that the main factor responsible for this decrease in density is flocculation of the soil structure, which increases with time of exposure of the soil to water and lime. The effect of greater flocculation is to increase the resistance to compaction. The increase in intensity of flocculation with time after lime addition may be attributed to the greater time available for lime to dissolve and other chemical reactions to occur. They also postulated that a delay between mixing and compaction is not detrimental as long as the compactive effort is increased to maintain constant density. McDowell (1959) states that soil-lime mixtures may be compacted any time within two days after mixing, with delays of up to four days permissible if heavy plastic clays are being stabilized.

Effect on Strength

Mitchell and Hooper (1961) have shown that soil-lime mixtures decrease in compressive strength as the time interval between

mixing and compaction increases. They found that if compaction was delayed 24 hours the strength decrease was as much as 30 percent of the strength of the specimens prepared immediately after mixing. It is true, however, that these strengths were determined for samples of progressively decreasing density.

McDowell (1959) pointed out that delay of compaction of all types of soil-lime mixtures will decrease hardening of the mix subsequent to compaction, because reaction prior to compaction will result in cementation of particles in a loose structure and subsequent compaction will break the bonds formed.

Effect on Plasticity

Almost every article on lime stabilization mentions the ability of lime to change the plasticity of the soil. When lime is added to a soil, the liquid limit normally decreases and the plastic limit increases with increased amounts of lime.

Lund and Ramsey (1959) performed an experiment involving the use of hydrated lime in the stabilization of plastic soils. They found that a clay with liquid limit of 51% and a plasticity index of 30% became non-plastic in two days with six percent of lime.

Herrin and Mitchell (1961) stated that the plasticity index is influenced by the length of time the lime reacts with the soil and the type of lime. A sizable reduction is usually noticed within the

result, or may justify the expenditure of more compaction effort to obtain high density; however, extra compactive effort means increased cost of compaction.

Effect on Volume Change

Mitchell and Hooper (1961) have shown that, for a clay-lime mixture, a delay between mixing and compaction is definitely detrimental in terms of swell for specimens prepared using constant compactive effort, hence a reduction in density.

Mitchell and Hooper (1961) also observed that a time interval of 24 hours between mixing and compaction has no detrimental effect on swell of lime-treated specimens which were compacted to the same density. Lime tended to reduce the volume changes that took place in soils.

II.3 FACTORS LIMITING THE USE OF LIME TO STABILIZE SOIL

Lime-soil mixtures have certain limitations that should be fully understood by the highway engineer before any design and construction of this type of stabilized road is undertaken. Herrin and Mitchell (1961) pointed out some of the more important limitations as being:

(1) Climatic conditions

(2) Permanency

(3) Thickness of treatment

(4) Resistance to traffic wear

(5) Cracking and Fluffing of lime-soil mixtures

(6) Construction limitations

(7) Reworking lime-soil mixtures

Climatic Conditions

Lime soil-mixtures have obtained satisfactory performance in areas with relatively mild temperature. In areas of colder climates the performance of these mixtures is not very well known.

Some investigations have indicated that air temperature materially influence the curing rate of lime-soil mixtures in the field. The curing rates of lime-soil mixtures are relatively fast at high temperatures, but are fairly slow at colder temperatures.

Herrin and Mitchell (1961) stated that freezing of lime-soil mixtures during curing may result in a permanent reduction in strength. This permanent loss in strength is due to the broken bonds between lime-soil particles because of the expansion of the frozen moisture and because of ice lenses in the mixture.

Permanency

Little is known of what happens when lime-soil mixtures are continually subjected to fluctuating ground water or to the percolation of water through the mixture for a long period of time. It is

possible that different reactions may take place when the mixture is leached with water containing sodium ions and other chemicals.

McDowell (1953) reported the results of testing lime-soil specimens that were cured for long periods of time. In many cases, he found that the plasticity indices of lime-soil mixtures in the field have increased slightly with age. He also found that the strengths of these mixtures tended to increase for a considerable period of time and then decrease slightly.

Thickness of Treatment

It is difficult to determine the minimum depth required for a lime-soil base, subbase or treated subgrade, because there are so many factors affecting this type of pavement, especially the variations in strengths attained in the field.

Anon (1954) suggested that lime-soil bases be not less than 6 inches thick in order to prevent excessive deflection under traffic. For subbase and treated subgrade, thicknesses have varied from a few inches to greater than 1 foot with varying success.

Resistance to Traffic Wear

Anon (1954) pointed out that lime-soil mixtures have little or no resistance to traffic wear. Moving vehicles abrade the surface of unprotected bases, which results in the undesirable loss of material. Lime-soil bases should be protected by an abrasion-

resistant surface; usually, a seal coat or a surface treatment is satisfactory.

Cracking and Fluffing of Lime-Soil Mixtures

Cracking is usually caused by volume changes in underlying untreated subgrades, by volume changes in the lime-soil mixtures or by the application of heavy loads or heavy rolling during the curing period.

Lund and Ramsey (1959) mentioned that even the volume changes of certain soils are minimized by treatment with lime, some natural shrinkage of lime-soil mixtures may still occur and a few cracks will result.

McDowell (1959) concluded that the natural shrinkage of lime-soil mixtures may be more severe in soils originally having low plasticity indices, but the exact amount will depend on the mineralogical composition of the treated material, quantity and type of lime used and curing conditions.

Fluffing or loosening of the surface of a lime-soil mixture occurs especially if the mixture is cured in the absence of moisture during hot weather. This loose material on the surface may prevent a tight bond between the lime-treated base and the surface course and will contribute to peeling of the surface treatment.

Construction Limitations

The performance of lime-soil mixtures is greatly influenced by construction techniques.

Herrin and Mitchell (1961) stated that many failures of lime-soil stabilized roads, especially those that occur along the outer edges of the pavements, have resulted from poor distribution of lime, inadequate depth control, lack of edge control and improper compaction. These could have been eliminated by proper construction techniques.

Reworking Lime-Soil Mixtures

Experience has indicated that reworking of lime-soil mixtures should be avoided after the mixture has set unless additional lime is added.

McDowell (1959) suggested that lime-soil mixtures be compacted within two to four days after mixing and that these mixtures not be reworked after 7 to 28 days without the use of additional lime. The time limit for reworking lime-soil mixtures without adding additional lime will depend on the field conditions and the quantity of lime originally added to the soil.

II.4 CLAY-ASPHALT STABILIZATION

Literature reviews pertaining to asphalt stabilization of sands are included in the theses of Pennell (1962), Jones (1962), and Knowles (1962). In the following paragraphs only the most important properties involving clay-asphalt stabilization will be reported.

Theories of Asphalt Stabilization

Endersby (1942) suggested two theories regarding the action of asphalt in waterproofing the soil. One is the "plug" theory which holds that the capillaries are simply plugged with bodies of asphalt, preventing the water from either entering or leaving. The other is the "intimate mix" theory, under which the individual particles are supposed to be coated with asphalt.

In dealing with fine-grained cohesive soil, however, it would appear that the "plug" theory is nearer the truth. The surface area of the particles is so large that no amount of asphalt ordinarily used could be expected to coat it completely. If large amounts of asphalt were used, the soil would become lubricated by the asphalt with resultant loss in stability.

Role of Asphalt in Clay-Lime Mixtures

In the case of fine-grained soils stabilized with lime, occasions may arise when such stabilized soils may possess adequate

strength but will not resist weathering. When asphalt is incorporated into these stabilized soils, the main purpose is to waterproof the soil mass and prevent the infiltration of water and the subsequent loss in strength that has been imparted by the secondary additive.

Puzinauskas and Kallas (1961) found that asphalt tends to retard the additive-soil reactions. The test results also indicate that soil-additive systems containing asphalt are less sensitive to variations in compaction water contents. They also point out that the strength of the cohesive soils is due principally to the cohesive interparticle bond. This bond is highly sensitive to action of water. Thus the asphalt films must be distributed throughout the soil mass in order to protect this inter-particle bond and thus preserve the strength of the soil mass.

Role of Water in Asphalt Stabilization

The presence of water during mixing and compaction phases of asphalt soil stabilization has long been recognized as an important factor. Cape (1940) showed that during mixing, water facilitates the even distribution of asphalt throughout the mass. The amount of moisture required for thorough distribution of cutback asphalt increases as the amount of fine material in the soil increases.

Katti, Davidson and Sheeler (1960) stated that the degree of cutback asphalt dispersion in a soil mass is a function of the

amount of water during the mixing. They also believed that the compaction of a soil-cutback asphalt-water system immediately following mixing produces a more stable product than a procedure in which a drying back period is included between mixing and compaction. The percentage of water required to produce maximum strength, maximum density, minimum total moisture absorption, and minimum expansion in the compacted specimens was different for each property mentioned. However, the range of water contents over which these minimum or maximum properties occurred was only several percent. Thus it was possible to select what was called a compromise mixing water content (CMC) at which the variance of each of the properties from the optimum value was a minimum. It was found that this compromise mixing water content was very close to the water content at which maximum standard AASHO density in the soil-cutback asphalt-water system occurred, and was dependent upon the soil type, the type of asphalt, and the amount of asphalt used in the mix.

Herrin (1958) indicated that for a silty sand, stabilized with MC-3 that the mix needed to be dried out before compaction to provide high initial stability. Although it is stated that drying is needed before mixture is compacted, too dry a mixture is not desirable. The drier the mixture is at the time of compaction, the

greater the air-void content and, consequently, the mixture is more susceptible to soaking up water.

Effects of Immersion on Clay-Lime-Asphalt Mixtures

On immersion in water after curing, water is undoubtedly imbibed very rapidly by those regions of the mixture which have not been adequately protected by asphalt; this should result in an initial rapid loss in strength. In view of the water sensitivity of the asphalt-soil mass bond, water should gradually find its way into the asphalt-soil mass[1] interface and destroy this bond; the rate of detachment should be dependent upon the firmness and extensiveness of the bond developed, and the fluidity of the asphalt. This would indicate that there should be, on continued water immersion, a further gradual reduction in strength due to the increase in water absorption. The rate of strength loss is greater for incompletely cured mixtures or those prepared with less viscous asphalts.

Curing of Clay-Lime-Asphalt Mixtures

It has been recognized in soil-additive mixtures stabilized with asphalt that a curing period is very important to obtain a stable material. Many methods have been used to cure these mixtures. Specimens may be cured at air temperature or at various elevated

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[1] Soil mass is used to define clay-lime mixtures.

temperatures prior to testing. Compacted samples may also be subjected to water immersion, to cycles of freezing and thawing or to cycles of wetting and drying before testing in order to ascertain the effects of climatic conditions on the mixtures.

Control should be exercised in the particular curing conditions used in any investigation, and caution should be used in attempting to apply test results to field conditions.

CHAPTER III

TESTING PROGRAM

III. 1 THE CONSTITUENTS

Soil

The soil used in this investigation, was a highly plastic clay from a borrow pit, 95 feet to the right of station 419 +00, highway 2-G-3, located near the town of Fahler, Alberta.

After being received from the field, the clay was thoroughly mixed and air-dried. The material was then sacked and stored in a dry room at normal temperatures.

An X-ray diffraction analysis performed by the Research Council of Alberta indicated that the soil contained illite as the principal clay mineral mixed with about equal amounts of Kaolinite and montmorillonite.[1]

According to the Unified Soil Classification, the soil was classified as a highly plastic clay (CH). Pertinent characteristics of this soil were:

Specific Gravity of Soil Solids	2.77
Liquid Limit - per cent	67.6

[1]Results as reported by Watt (1961).

Plastic Limit - per cent	27.9
Plasticity Index - per cent	39.7

The procedures followed to determine the specific gravity and the Atterberg Limits are outlined in appendix A.

A grain-size analysis of the soil was performed in accordance with procedures outlined in appendix A. The results of this analysis are:

Material	Limiting Diameters	Per Cent
sand sizes	greater than 0.06 mm.	15
silt sizes	0.002 mm. to 0.06 mm.	30
clay sizes	less than 0.002 mm.	55

Lime

In a restricted scientific sense, "lime" is the oxide of calcium, CaO, and it is commercially produced by "lime-burning" or calcining crushed limestone.

Quicklime (or lime) readily reacts with water to produce calcium hydroxide which is commonly known as slaked lime or hydrated lime. The hydration of quicklime is generally performed by adding sufficient water to quicklime to satisfy its chemical affinity for water.

The lime used in this investigation was a commercial hydrated calcitic lime supplied by Loders Lime (Alberta) Limited.

The specific gravity of the lime determined using procedures outlined in appendix A, was 2.25. The average moisture content of the lime was 0.73 per cent, which was the total moisture driven off at temperatures of 115^{C}.

The chemical analysis of the lime was performed by Loders Lime Limited and show the following properties:

Compound	Per cent
CaO	74.8
MgO	1.2
FeO_2, AlO_2	0.4
SiO_2	0.3
Ignition Loss	22.9

Asphalt

The cutback asphalt was supplied by Husky Oil and Refining Company Limited of Lloydminster, Alberta. The analysis of the MC-3 cutback asphalt was performed by the supplier and was as follows:

Specific Gravity at 60°F.	0.9820
API Gravity at 60°F.	12.6
Flash Point (T.O.C.) - °F	150 +
Water - %	Nil
Saybolt Furol Viscosity at 140°F. - sec.	442

Distillation

	% of Total Over	% of Distillate Total Over
437°F.	0	0
500°F.	2.5	12.5
600°F.	13.0	65.0
680°F.	20.0	100.0

Residue to 680°F. volume by difference - %	80.0
Residue Penetration at 77°F. (100 gms., 5 sec.)	189
Oliensis Spot Test (15% Xylene)	Negative
Soluble in Carbon Tetrachloride - %	99.8+
Ductility at 77°F. (5 cm. per min.) - cm.	100

Water

Distilled water was used throughout the program to eliminate the variable that might result from impurities added with ordinary tap water.

III.2 SCOPE OF THE TESTING PROGRAM

This program was divided into two portions. One series of the test investigated the strength of clay-lime-asphalt mixtures after 7 and 28 days curing at room temperature and 1 day of soaking. The second series was performed in order to determine the loss in strength of these mixtures and their resistance to water for immersion periods of 7 and 14 days.

The additive contents, that is, the sum of the dry weight of lime and asphalt, were 8 and 10 per cent of the dry weight of the clay, which respectively represented 5 per cent of lime and 3 per cent MC-3 asphalt, 5 per cent of lime and 5 per cent MC-3 asphalt.

Between mixing and compaction a delay of 1, 2, 3, and 4 days was allowed. During this interval of time only the 5 per cent of lime was added to the clay. The asphalt was added just before the compaction.

Cylindrical 2-in. by 4-in.[1] specimens of each mixture were prepared by compacting the specimens in four equal layers with a compactive effort of 10 blows per layer of the standard compaction hammer (5.5-lb. and 12-in. drop).

The specimens cured at room temperature and the ones immersed in water were designated by the letters A and B respectively. The first number before the letter represented the percentage of asphalt. The second one denoted the delay between mixing and compaction. The number of the specimen was after the letter. Because the amount of lime was always the same, 5 per cent, this value did not figure in the designation. For example, a sample marked 31A4, indicated the specimen contained 3 per cent of asphalt and 5 per cent of lime; was pretreated 1 day before compaction; was

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[1]Cylindrical 2-in. in diameter by 4-in. in height.

cured at room temperature; and was the specimen number 4. A specimen, marked 54B12 contained 5 per cent of asphalt and 5 per cent of lime; was pretreated 4 days before compaction; was immersed into water; and was the specimen number 12.

The program was organized so that each result was the average of six specimens. The results obtained from the program included the dry density and the moisture content at failure, and the unconfined compressive strength after 7 and 28 days of curing at room temperature and 24 hours of soaking the specimens. In the case of specimens immersed in water, the results also included the dry density and the moisture content at failure, the change in volume and the water absorption after 7 and 14 days immersion, and the unconfined compressive strength after 7 and 14 days immersion.

III. 3 TESTING PROCEDURES

Mixture Proportions

The proportions of the highly plastic clay, lime and asphalt components of mixtures were based on the oven dry weight of the clay. The desired moisture content was fixed at 1. 5 per cent higher than the optimum density-moisture condition determined from clay-lime specimens which had undergone a rotting period of 1, 2, 3, and 4 days between mixing and compaction.

Mixing

Mixing of batches for preparing test specimens could be divided into two phases. During the first phase the appropriate weights of air dry natural[1] soil and lime were hand mixed in a large aluminum pan less than 3 minutes. Sufficient distilled water was then added to the dry mixture from a spray bottle to give the desired water content. Usually the wet mixing was completed in 10 minutes. The mixed samples were then covered with polyethylene plastic sheet and stored in a humid room until needed for the second phase.

The first five minutes of the second phase, that is, after the rotting period, was spent in pulverizing the larger clods. The cutback asphalt, having been heated to 170°F and weighed to the nearest gram, was added to the clay-lime mixture. The mixture was then stirred by hand for 17 minutes. At the end of the mixing time, the soil mixture was compacted.

To obtain 12 specimens, the batch was calculated to yield enough soil for an additional specimen. The extra portion was used to determine the moisture content.

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[1]Natural means that the clay was not passed through sieves, and contained some large clods up to 3 inches in size.

Compaction

Compaction was carried out at 1, 2, 3, and 4 days after the end of the initial mixing period. Twelve cylindrical 2-in. by 4-in. specimens of each mixture were prepared by compacting the specimens in four equal layers with a compactive effort of 10 blows per layer of the standard compaction hammer (5.5-lb. and 12-in. drop), using the apparatus shown in Plate 1a. The extrusion of the specimens was accomplished with the hydraulic apparatus portrayed in Plate 1b.

Initial Measurements

The specimen removed from the mold, was weighed to the nearest 0.01 grams. When all the specimens from each batch were compacted and extruded, they were measured in height and in diameter to the nearest 0.001 inches. The height and the diameter of each cylinder were measured by means of a calliper. Usually two measurements were taken at right angles each other. The average of the two measurements was recorded. The specimens were then immediately sealed[1] in polyethylene bags.

Curing

Specimens were cured at room temperatures (70±4°F) for 7 or 28 days. Since the specimens were sealed in polyethylene

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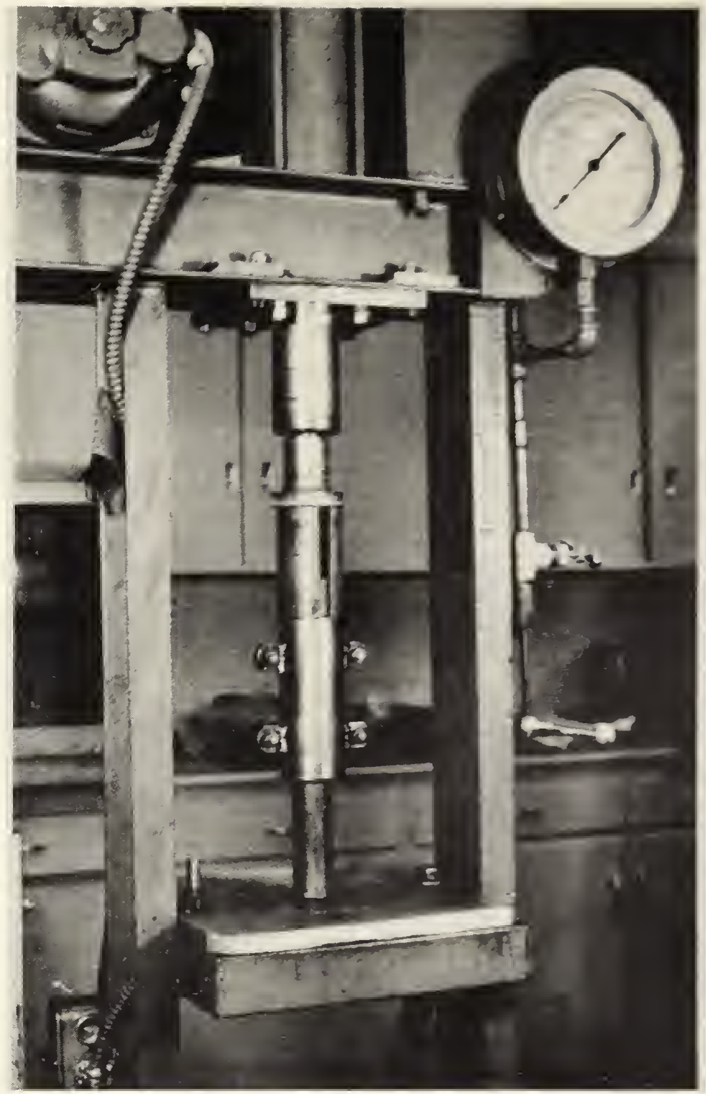
[1]The bags were sealed by folding down the open end and tying with a string.

COMPACTION APPARATUS
Plate la



EXTRUSION APPARATUS
Plate lb

bags, the loss of moisture and absorption of carbon dioxide from the air was reduced.

Soaking

After each curing period, specimens were removed from the bags; were weighed to the nearest 0.01 grams; were measured to the nearest 0.001 inches; and were immersed in distilled water for a period of 24 hours, plus or minus 2 hours. The specimens were placed in a large pan which was filled with water to a level about 1 inch above the tops of the specimens.

Immersion Test

A series of specimens, after having been removed from the mold, were weighed to 0.01 grams; were measured in height and in diameter to 0.001 inches; and then placed in a metal tank filled with distilled water. Throughout the test, water was added in order to keep the water level 1 inch above the tops of the specimens. The specimens were immersed in water during a period of 7 days and 14 days.

Final Measurements

After each immersion period and soaking period, the surface water on the specimens was removed by means of a paper towel; the diameter and height of the specimens were measured and the weight was recorded to the nearest 0.01 grams.

The diameter and height were measured using the same calliper that was used in the initial measurements. Two diameters and two lengths at right angles to each other were measured and the average values were recorded to the nearest 0.001 inches.

Unconfined Compression Test

The specimens were tested for unconfined compressive strength using a Tinius Olsen Hydraulic Compression Testing Machine. The specimen was placed onto the bed of the testing machine, where it was centered under the loading head. The specimen was then broken at a rate of strain of 0.104 inches per minute. At failure, the strain reading was taken and the time was registered. The arrangement of the apparatus and specimen is portrayed in Plate 2.

The unit strain was calculated, and used in the computation of the area at failure using the following equation:

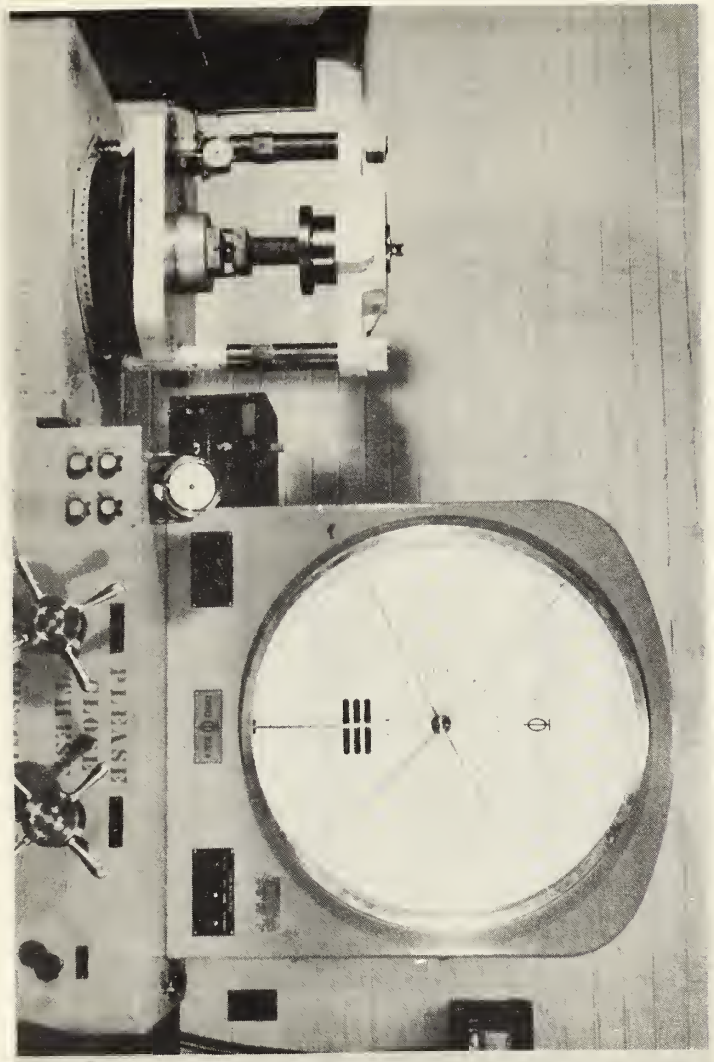
$$A_c = \frac{A_o}{1 - e}$$

where A_c was the corrected area,

A_o was the area calculated from the final measurements,

and e was the unit strain at failure.

The load on the cylinder was given directly, in kilograms, on the dial of the testing machine. A multiplying factor of 2.2 was used to convert the load in kilograms to pounds.



COMPRESSIVE STRENGTH TEST
Plate 2a

LOADING HEAD APPARATUS
Plate 2b

The moisture content of the mixture was determined after failure of the specimen.

III. 4 DISCUSSION OF PROCEDURES

Mixing Moisture Content

Moisture-density relationships on clay-lime-asphalt mixtures had shown that these mixtures had their optimum densities at moisture contents of 24.0 per cent and 24.5 per cent with 5 per cent and 3 per cent of asphalt respectively. To obtain the desired moisture content, after the second phase of mixing prior to compaction, a certain additional amount of water was needed during the first phase of mixing prior to the rotting period. After several attempts, the moisture content was fixed at 1.5 per cent higher than the optimum-density condition determined from clay-lime specimens which had undergone a rotting period of 1, 2, 3 and 4 days between mixing and compaction.

Moisture-density relationships on clay-lime-asphalt are given in appendix B.

Mixing

Attempts to mix clay-lime mixed samples and asphalt in a mechanical pugmill were unsuccessful because the mixture tended to form large clods.

Watt (1961) pointed out that many clay-lime mixtures with high lime content were well mixed, by hand, in 20 minutes. In the case of clay-lime-asphalt mixtures, however, with low lime content, the full half hour was required.

The delay between the first mixing and the one prior to compaction permitted the break down of the clay clods, improved the mix uniformity, and facilitated the final mixing.

The Rotting Period

Variable rotting periods of 1, 2, 3, and 4 days between mixing and compaction were allowed. The results of varying the rotting time are shown in appendix B. The results showed that a rotting period reduced the dry density of the compacted specimens, and decreased the strengths of clay-lime mixtures which were cured for 7 days at room temperature.

Compaction

The specimens were compacted in four equal layers with a compactive effort of 10 blows per layer of the standard compaction hammer. This compactive effort for the 2-in. by 4-in. cylindrical specimens has been determined [1] to achieve a density equal to the standard Proctor compaction test.

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[1] Research Council of Alberta.

Curing and Soaking

Clay-lime-asphalt mixtures increase in strength with age. Usually, there is a rapid increase in strength at the beginning of the curing period, but as the curing progresses the rate of increase in strength becomes less and less. In this study, curing periods of 7 days and 28 days were selected in order to show the rate of increase in strength with time.

The specimens cured at room temperature were immersed in distilled water for 24 hours after curing and before being tested for strength. The immersion period was intended to reduce or destroy any apparent cohesion in the soil in order to test the true cohesion and other stabilizing effects of the soil-lime-asphalt mixture.

Immersion

Water immersion periods were not intended to depict a condition that is likely to occur in a roadbed. The samples were immersed completely in order to assure an uniform degree of saturation throughout the specimen. The main purpose of the water immersion test was to evaluate the waterproofing effects of the asphalt.

This water immersion test could be considered very severe in that the specimens were not allowed to cure after compaction and prior to immersion, thus only the first of the three types of chemical reactions had time to occur.[1]

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[1]See page 4.

Dry Density

During fabrication of specimens, moisture contents were taken after the third and the ninth samples. The first moisture content was used as the average molding moisture content of the first six specimens in computing dry density, and the second moisture content was used as the average molding moisture content of the last six specimens.

The initial dry density was calculated by means of the equation:

$$\gamma = C \times \frac{W}{(1 + w)\,H}$$

where W was the wet weight of the specimen in grams,

H was the height of the specimen in inches,

w was the molding moisture content as a decimal,

γ was the dry density in pounds per cubic foot,

and C was a constant dependent upon the diameter of the mold. Values for C and the diameter of the molds are given in tabular form as follows:

Mold Number	Diameter in inches	C
1	2.001	1.2113
2	2.006	1.2047

CHAPTER IV

RESULTS OF THE TESTING PROGRAM

The significant results, accumulated in the test program, are presented in Tables I to VII. Tables I and II display the average values of the 7-day and 28-day strengths for the stabilized clay-lime-asphalt specimens which had been soaked the full day before the strength tests. Table III and Table IV show the average values of the 7-day and 14-day strengths for the stabilized specimens which had been immersed in water without a prior curing period. Void properties of the immersed specimens are reported in Tables V, VI, and VII.

The Tables also include the percentages of volume changes and water absorptions[1] experienced during the soaking periods, the molding moisture contents, the moisture contents at failure, and the dry densities as compacted.

A discussion of the effect of the asphalt upon the unconfined compressive strength is presented.

A discussion involving void properties of clay-lime-asphalt specimens is also included.

A discussion of the effect of the rotting period upon clay-lime-asphalt stabilized specimens concludes the chapter.

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[1]The percentage of water absorption was the difference between the weight of the specimen before and after immersion over the weight of the specimen before immersion multiplied by 100.

TABLE I

SUMMARY OF TEST RESULTS

7-DAY STRENGTH TESTS OF SPECIMENS CURED AT ROOM TEMPERATURE

Sample No.	Pretreating Period days	Lime Content %	Asphalt Content %	Initial Moisture Content %	Final Moisture Content %	Initial Dry Density pcf	Unconfined Compressive Strength psi	Water Absorption %	Increase in Volume %
51A1 - 6	1	5	5	24.5	24.78	92.8	50.3	0.85	---
52A13 - 18	2	5	5	24.3	26.7	91.0	29.5	0.49	---
53A25 - 30	3	5	5	23.7	24.66	93.4	34.6	0.60	---
54A37 - 42	4	5	5	24.3	24.2	92.9	45.0	0.52	---
31A49 - 54	1	5	3	24.3	20.55	94.7	40.7	2.36	2.10
32A61 - 66	2	5	3	24.3	22.75	94.1	37.7	2.45	2.41
33A73 - 78	3	5	3	24.2	27.0	94.8	34.7	2.58	2.37
34A85 - 90	4	5	3	25.1	27.6	93.6	27.5	2.79	2.39

Note:- Each result is the average of six specimens.

TABLE II

SUMMARY OF TEST RESULTS

28-DAY STRENGTH TESTS OF SPECIMENS CURED AT ROOM TEMPERATURE

Sample No.	Pretreating Period days	Lime Content %	Asphalt Content %	Initial Moisture Content %	Final Moisture Content %	Initial Dry Density pcf	Unconfined Compressive Strength psi	Water Absorption %	Increase in Volume %
51A7 - 12	1	5	5	24.7	25.5	92.4	63.5	1.16	1.08
52A19- 24	2	5	5	23.6	24.28	92.6	47.5	0.89	0.64
53A31 - 36	3	5	5	24.2	23.55	93.2	42.9	0.68	0.35
54A43 - 48	4	5	5	24.3	22.2	93.3	59.0	0.67	0.42
31A55 - 60	1	5	3	24.3	24.63	94.5	75.9	1.18	1.12
32A67 - 72	2	5	3	24.2	25.3	94.2	70.96	1.48	1.44
33A79 - 84	3	5	3	24.2	24.9	94.7	64.0	1.42	1.45
34A91 - 96	4	5	3	24.7	25.53	93.9	68.9	1.34	1.41

Note:- Each result is the average of six specimens.

TABLE III

SUMMARY OF TEST RESULTS

7-DAY STRENGTH TESTS OF SPECIMENS IMMERSED IN WATER

Sample No.	Pretreating Period days	Lime Content %	Asphalt Content %	Initial Moisture Content %	Final Moisture Content %	Initial Dry Density pcf	Unconfined Compressive Strength psi	Water Absorption %	Increase in Volume %
51B97 - 102	1	5	5	27.9	36.8	92.4	11.9	6.61	12.36
52B109-114	2	5	5	25.9	35.3	94.3	10.99	6.66	12.70
53B121-126	3	5	5	26.3	36.2	93.2	12.0	6.10	12.35
54B133-138	4	5	5	26.1	35.3	93.9	10.13	7.21	13.33
31B145-150	1	5	3	25.9	35.5	95.2	15.17	6.80	13.64
32B157-162	2	5	3	24.7	35.15	95.8	13.09	6.38	12.09
33B169-174	3	5	3	26.5	35.46	94.1	12.39	6.49	12.94
34B181-186	4	5	3	25.9	34.95	93.5	9.57	7.69	12.37

Note:- Each result is the average of six specimens.

TABLE IV

SUMMARY OF TEST RESULTS

14-DAY STRENGTH TESTS OF SPECIMENS IMMERSED IN WATER

Sample No.	Pretreating Period days	Lime Content %	Asphalt Content %	Initial Moisture Content %	Final Moisture Content %	Initial Dry Density pcf	Unconfined Compressive Strength psi	Water Absorption %	Increase in Volume %
51B103 -108	1	5	5	27.8	42.46	92.4	9.54	10.84	20.57
52B115 -120	2	5	5	25.6	41.3	94.3	8.0	10.83	19.60
53B127 -132	3	5	5	26.2	41.23	93.2	8.56	9.99	18.99
54B139 -144	4	5	5	25.8	39.6	94.0	7.0	10.89	19.04
31B151 -156	1	5	3	25.8	36.5	94.9	15.49	8.12	15.48
32B163 -168	2	5	3	24.5	37.4	96.0	13.84	8.48	15.64
33B175 -180	3	5	3	26.3	38.5	94.0	9.99	9.21	16.03
34B193 -198	4	5	3	25.9	40.3	93.2	8.67	9.39	18.7

Note:- Each result is the average of six specimens.

TABLE V

SUMMARY OF TEST RESULTS

VOID PROPERTIES BEFORE IMMERSION

Sample No.	Wt. Wet Sample gm.	Wt. Dry Sample gm.	Wt. Water gm.	Wt. Additives gm.	Volume Sample cc	Vol. Soil Solids cc	Volume Voids cc	Voids Filled With Asphalt %	Voids Filled With Lime %	Voids Filled With Water %	Total voids as % of total mix
51B97 -102	395.51	309.20	86.31	25.4	208.5	102.3	106.2	10.70	5.91	81.3	50.9
52B109-114	396.90	315.60	81.30	26.8	209.0	104.2	104.8	11.62	6.32	77.5	50.2
53B121-126	393.78	311.10	82.68	25.6	208.5	103.1	105.4	11.0	5.99	78.3	50.5
54B133-138	396.68	314.80	81.88	26.3	210.0	104.1	105.9	11.26	6.14	77.3	50.4
31B145-150	400.43	318.00	82.43	22.0	209.5	106.9	102.6	7.10	6.45	80.2	49.0
32B157-162	400.05	320.80	79.25	23.0	209.9	107.1	102.6	7.66	6.63	77.3	48.9
33B169-174	398.03	315.00	83.03	21.8	208.5	105.8	102.7	7.03	6.38	81.0	49.2
34B181-186	394.16	313.20	80.96	21.9	210.5	105.1	105.4	6.86	6.24	76.7	50.1

Note:- Each result is the average of six specimens.

TABLE VI

SUMMARY OF TEST RESULTS

VOID PROPERTIES AFTER 7-DAYS IMMERSION .-

Sample No.	Wt. Wet Sample gm.	Wt. Dry Sample gm.	Wt. Water gm.	Wt. Additives gm.	Volume Sample cc	Vol. Soil Solids cc	Volume Voids cc	Voids Filled With			Total Voids as % of Total Mix
								Asphalt %	Lime %	Water %	
51B97 -102	419.10	306.34	112.76	25.34	234.5	101.5	133.0	8.62	4.72	84.8	56.7
52B109-114	420.60	310.95	109.65	25.95	235.5	102.9	132.6	8.40	4.83	82.7	56.3
53B121-126	415.89	304.48	111.41	25.0	234.5	100.9	133.6	8.48	4.61	83.4	56.9
54B133-138	423.18	312.79	110.38	25.9	237.5	103.5	134.0	8.83	4.77	82.3	56.4
31B145-150	425.48	314.18	111.30	21.7	237.0	105.6	131.4	5.48	4.96	84.7	55.5
32B157-162	423.61	313.50	110.11	22.0	235.0	105.2	129.8	5.62	5.08	84.9	55.2
32B169-174	421.33	311.21	110.12	21.7	235.5	104.5	131.0	5.48	4.98	84.1	55.7
34B181-186	421.23	312.10	109.13	21.5	236.0	104.9	131.1	5.41	4.92	83.3	55.6

Note:- Each result is the average of six specimens.

TABLE VII

SUMMARY OF TEST RESULTS

VOID PROPERTIES AFTER 14-DAYS IMMERSION. -

Sample No.	Wt. Wet Sample gm.	Wt. Dry Sample gm.	Wt. Water gm.	Wt. Add-itives gm.	Volume Sample cc	Vol. Soil Solids cc	Volume Voids cc	Voids Filled With			Total Void as % of Total Mix
								Asphalt %	Lime %	Water %	
51B103-108	435.59	305.54	130.05	25.54	252.5	101.1	151.4	7.64	4.17	85.9	60.0
52B115-120	437.11	309.33	127.78	25.35	251.5	102.5	149.0	7.70	4.21	85.7	59.2
53B127-132	430.72	305.12	125.60	25.12	249.5	101.1	148.4	7.66	4.18	84.6	59.5
54B139-144	435.90	312.27	123.63	25.29	251.0	103.5	147.5	7.77	4.24	83.8	58.7
31B151-156	428.66	314.19	114.47	21.69	242.0	105.6	136.4	5.26	4.77	84.0	56.4
32B163-168	431.17	313.85	117.32	21.85	242.5	105.4	137.1	5.27	4.78	85.5	56.6
33B175-180	431.31	311.14	120.17	21.15	244.5	104.6	139.9	5.01	4.54	86.0	57.2
34B193-198	431.92	307.98	123.94	21.58	249.5	103.3	146.2	4.89	4.43	84.6	58.6

Note:- Each result is the average of six specimens.

A summary of data sheets is contained in appendix E of this study.

IV. 1 DISCUSSION OF STRENGTH RESULTS

The average compressive strength in lb per sq in was 40 and 75 respectively for 7-day and 28-day specimens cured at room temperature and compacted at the equivalent standard Proctor compactive effort. The 28-day specimens were, therefore, about twice as strong as the 7-day specimens. These values were obtained after a full day immersion before strength tests and for mixtures which contained 5 per cent of lime and 3 per cent of asphalt (or 2.4 per cent of residual asphalt).

When these mixtures were immersed in water 7 days and 14 days, immediately after compaction, their strengths were reduced to 15 lb per sq in.

Figures 16 and 18, in appendix B, show that the unconfined compressive strengths of clay-lime mixtures are markedly influenced by the presence of asphalt. Asphalt decreases the optimum strength of the compacted specimen. This loss in strength may be attributed to the reduction of cohesive interparticle bonds by the asphalt films distributed through the compacted mass. These films may act as an interparticle lubricant, resulting in a weakening of the compacted mass. It can be expected that a greater number of asphalt films will proportionately

destroy more of such bonds and, therefore, results in a more pronounced reduction of compressive strength.

Another interesting observation can be made from the comparisons of strength characteristic of the two systems. The curves obtained by plotting strength against compaction water or liquid content are flatter when asphalt is present in the mixture. This means that the strengths of such asphalt containing systems are affected less by the variations in the compaction liquid content. Considering such behavior from a practical view point, it indicated that the mixtures containing asphalt will compact to a layer of more uniform strength even when the water is distributed less uniformly throughout the soil mass.

Figures 1, 2, 3, and 4 indicate that gradually increasing amounts of additive [1]progressively lower the compressive strengths of the specimens. The reasons for such behavior were described previously and it is believed that the results represented in these figures confirm these reasons.

Puzinauskas and Kallas (1961) pointed out, however, that such trends may be reversed when cohesive soils of less uniform gradation are used.

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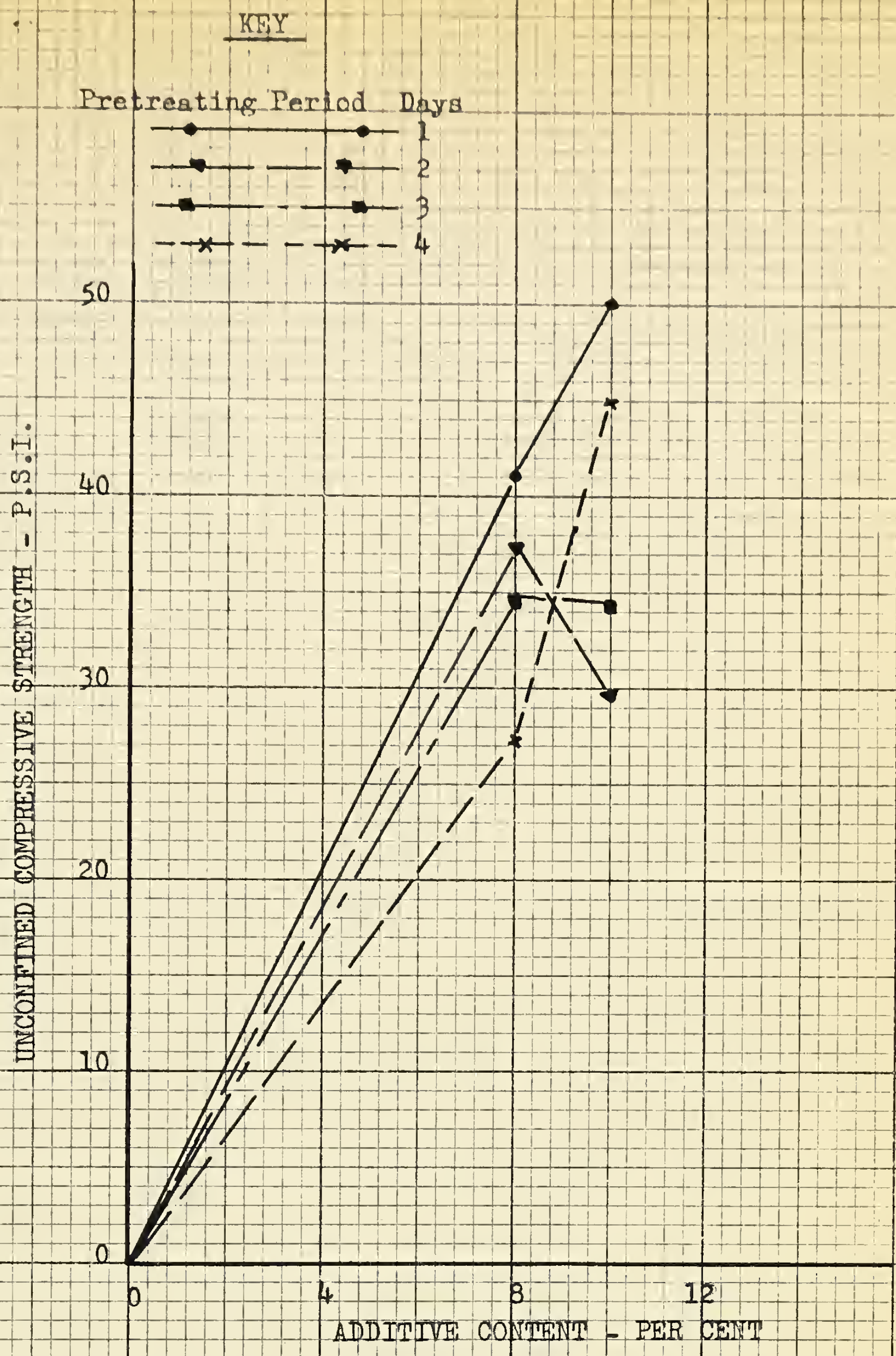
[1]When the additive content increases only the percentage of asphalt increases because the lime content is kept at 5 per cent.

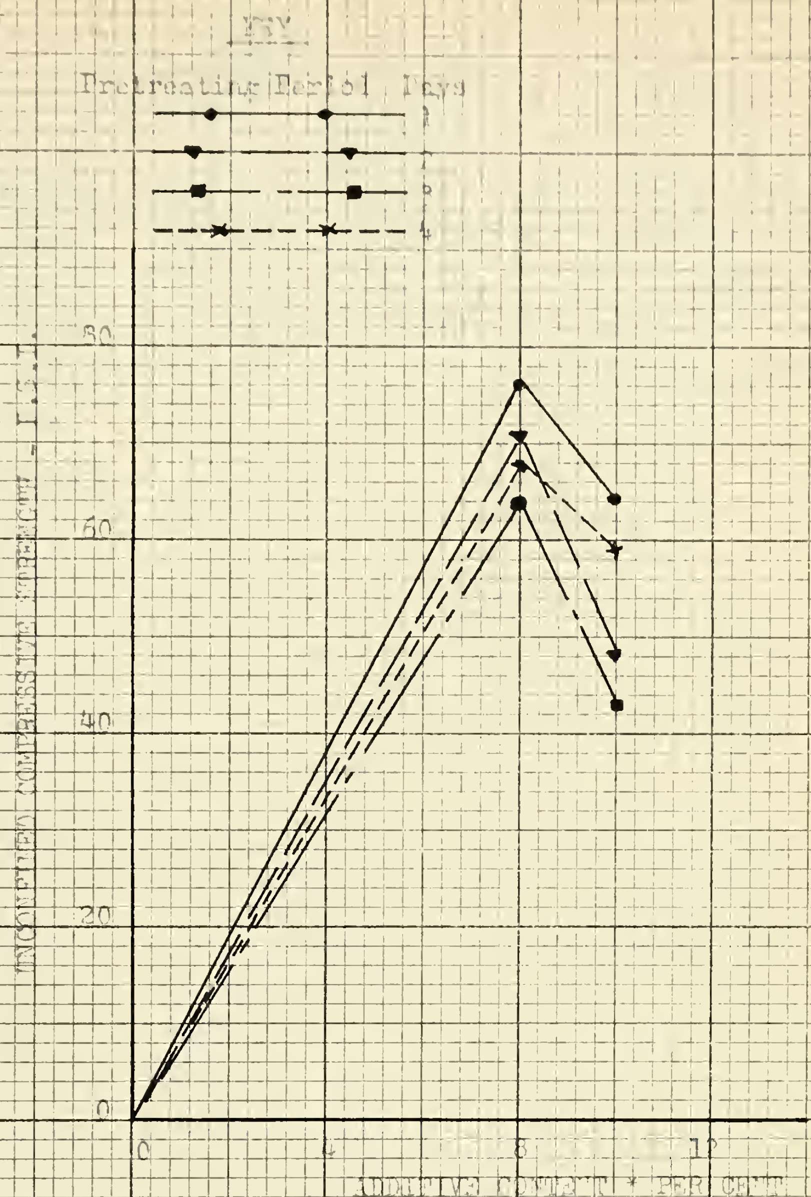


UNCONFINED COMPRESSIVE STRENGTH VS ADDITIVE CONTENT

Standard Proctor Compactive Effort

Curing Time 7 Days; Soaking Time 1 day

FIGURE 1

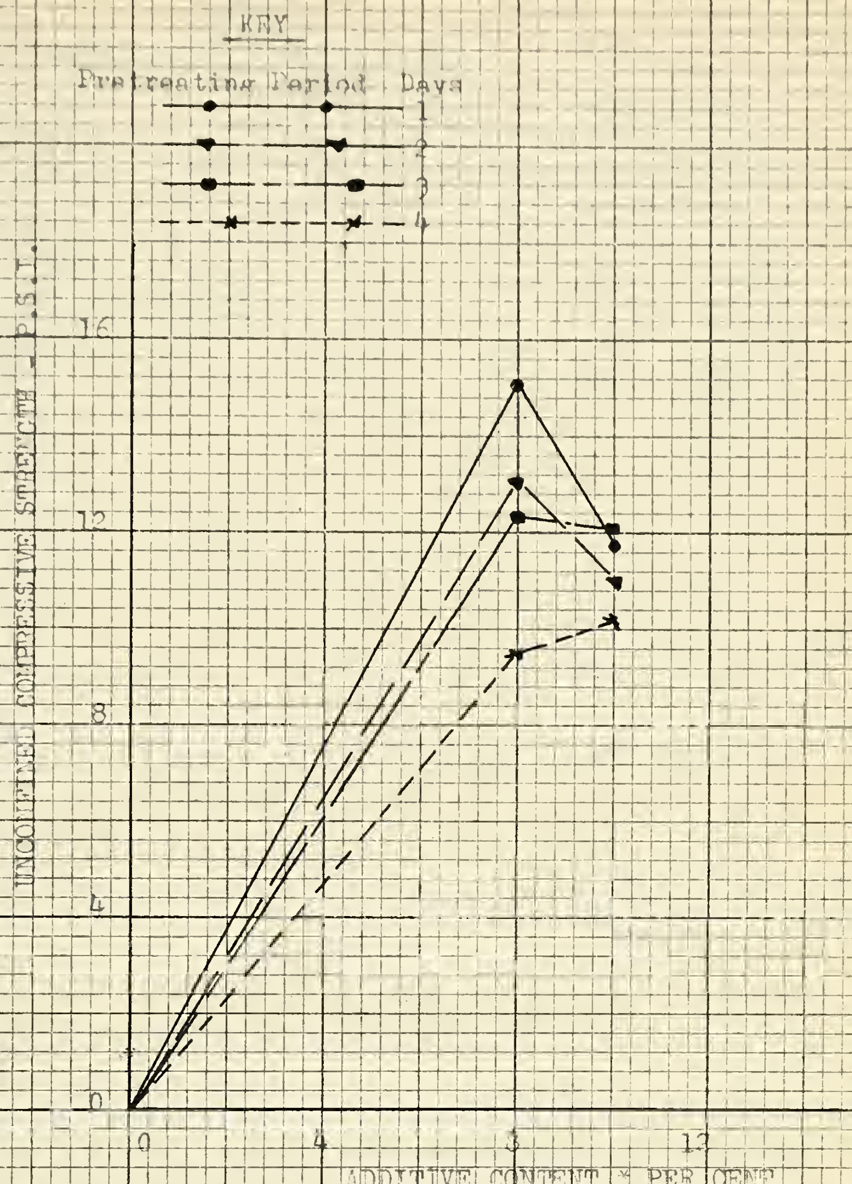


UNCONFINED COMPRESSIVE STRENGTH VS ADDITIVE CONTENT

Standard Proctor Compactive Effort

Curing Time 28 Days; Soaking Time 1 Day

FIGURE 2

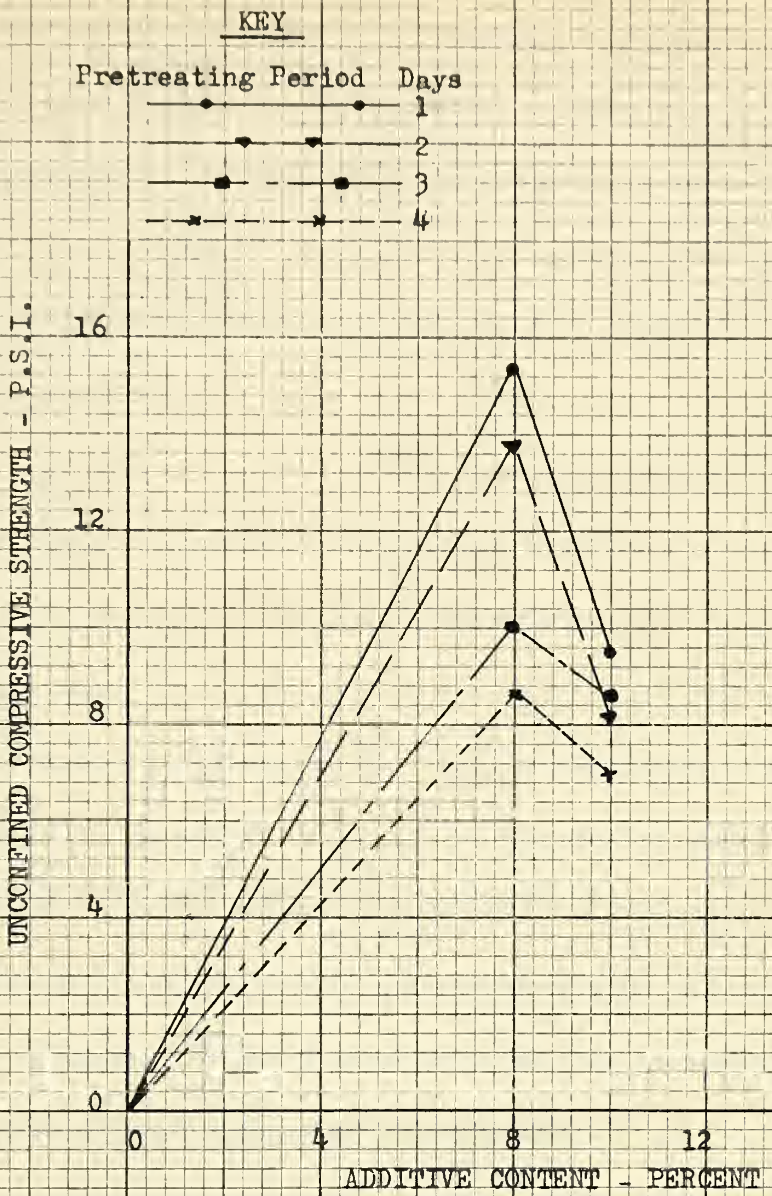


UNCONFINED COMPRESSIVE STRENGTH VS ADDITIVE CONTENT

Standard Proctor Compactive Effort

Immersion Time 7 Days

FIGURE 3



UNCONFINED COMPRESSIVE STRENGTH VS ADDITIVE CONTENT

Standard Proctor Compactive Effort

Immersion Time 14 Days

FIGURE [illegible]

Figure 17, in appendix B, shows that increasing asphalt content in the mixture results in decreased density of the compacted specimen. It is evident, that when more asphalt is used, replacement of compaction water or volatiles by the asphalt is more pronounced. This means that when more asphalt is used in the soil-lime-water mixtures, drier soil must be used in order to obtain the maximum compaction densities.

Tables I, II, III, and IV also show this phenomena. Initial dry densities calculated from mixtures containing 5 per cent of asphalt are lower than those calculated from mixtures where 3 per cent of asphalt was used.

It is interesting to note that the maximum strengths for the systems with or without asphalt are obtained at less than optimum liquid content, whether asphalt is present or not (figures 16 and 18). This points out the similarity in physical behavior of these two systems.

Figures 16 and 18 also show that the optimum water content is lower when asphalt is present in the mixture.

IV.2 EFFECTS OF WATER IMMERSION ON THE PROPERTIES OF CLAY-LIME-ASPHALT MIXTURES

For the design of cohesive soil-lime-asphalt mixtures, it is believed that the change in strength of the soil during immersion should be considered. The immersed strength could be used as an

indication of the load-bearing qualities of the stabilized soil layer, and the change in strength upon immersion would indicate the water-proofing effects of asphalt which in turn would also reflect the weathering properties of the stabilized layers.

Regardless of asphalt content used, the reduction in strength by immersion is evident (figures 1 and 3). However, it should be kept in mind that compacted clay-water specimens without lime and asphalt disintegrate within 24 hours upon immersion.(Watt, 1961)

Closer examination of Tables III and IV disclose the fact that the moulding moisture contents (initial moisture contents) used for specimens to be immersed were above the optimum values. This discrepancy was not intended and was due to a mistake in the calculations but is not considered to have significant effects on the results. Puzinauskas and Kallas (1961) reported that, in the case of fine-grained water-sensitive soils, compaction water contents at or somewhat above optimum may be favorable.

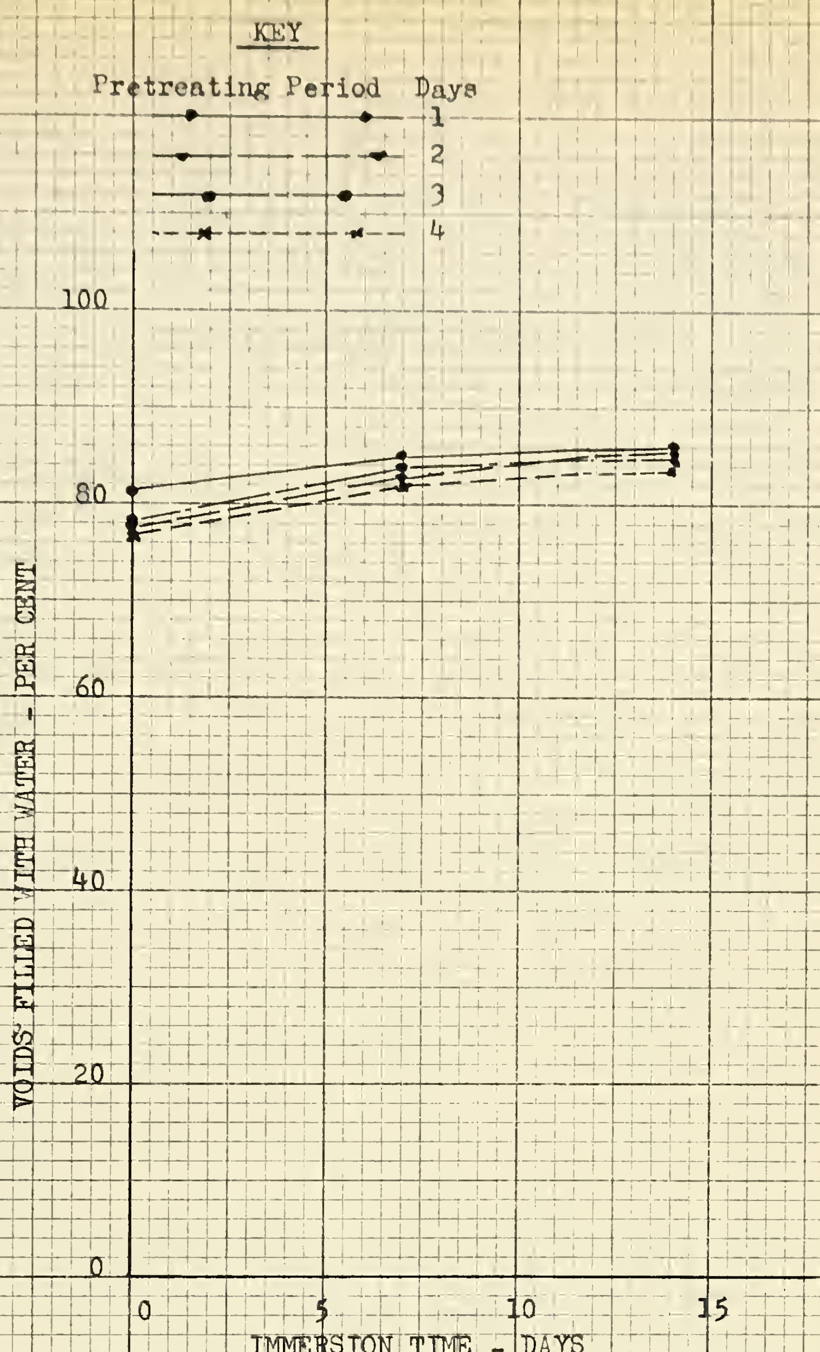
Figures 6 and 8 show the effect of asphalt and hydrated lime on the percentage of void space filled with asphalt, lime and water during the 14 days immersion period. These plots indicate a slight decrease, followed by an increase in the volume of air voids in the mixture is caused by increasing the immersion period. It is believed that the changes represented in these figures may be attributed to the rate of water absorption. Figures 10 and 13 show

that the rate of water absorption appears to be rapid during the first days of the immersion period with the rate decreasing slightly with further immersion.

Tables V, VI, and VII indicate that a very slight increase in the volume of voids in the mixture is caused by increasing asphalt content. Since these variations are small, it can be said that the influence of asphalt on the mixture voids is negligible.

Figures 5 and 7 give the effect of hydrated lime and asphalt on the percentage of void space filled with water during the 14 days immersion period. It appears to be very little change in the percentage of void space filled with water for the various asphalt contents. Knowles (1962) also found the same relationship with sand-lime-asphalt mixtures. However, when no hydrated lime was used in the mixture, he noticed that the voids filled with water were markedly reduced by increasing asphalt content. It seems, therefore, that the hydrated lime tends to reduce the effect that the asphalt content has on the amount of water absorbed by the compacted mix.

Table I and II reveal that the percentage of water ab-



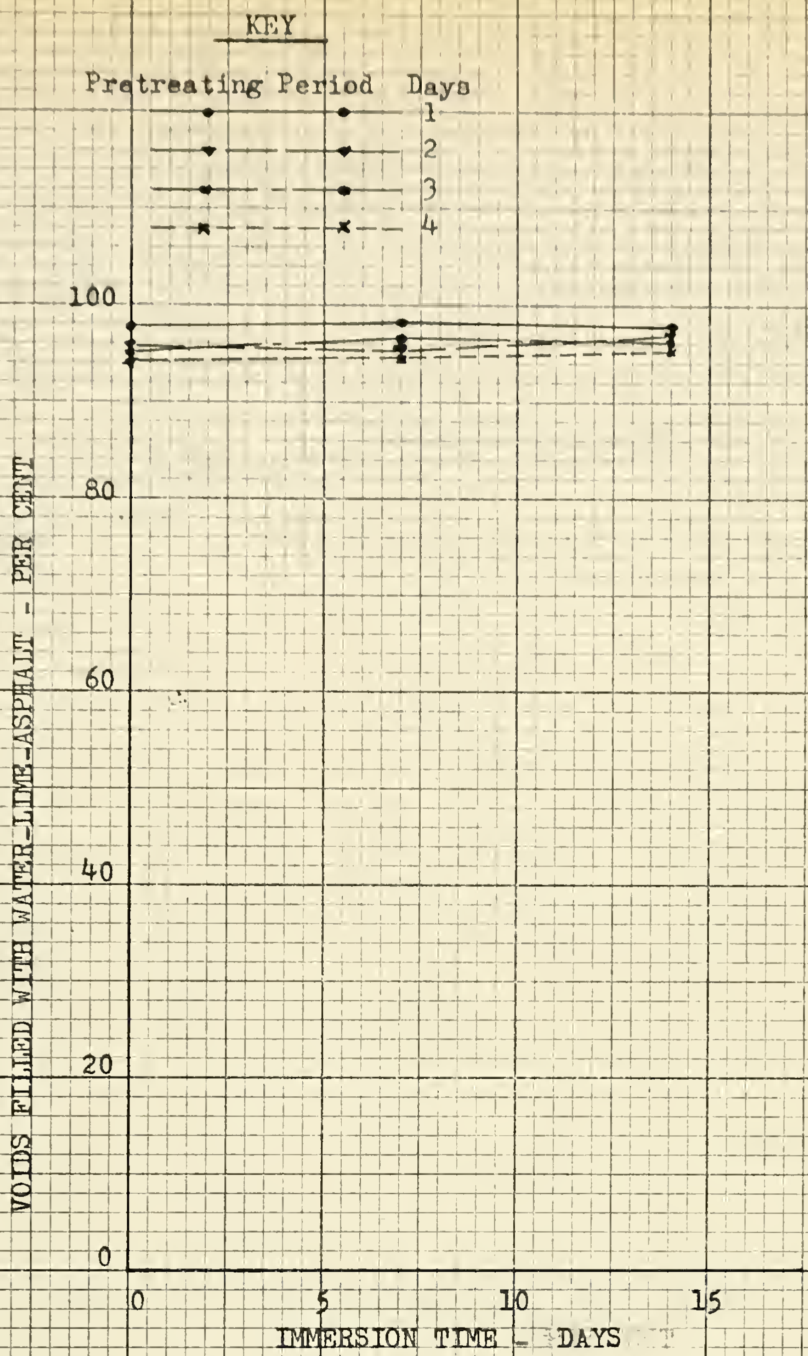
VOIDS FILLED WITH WATER VS IMMERSION TIME

Standard Proctor Compactive Effort

ADDITIVE CONTENT:- 5% MC-3

5% LIME

FIGURE 5

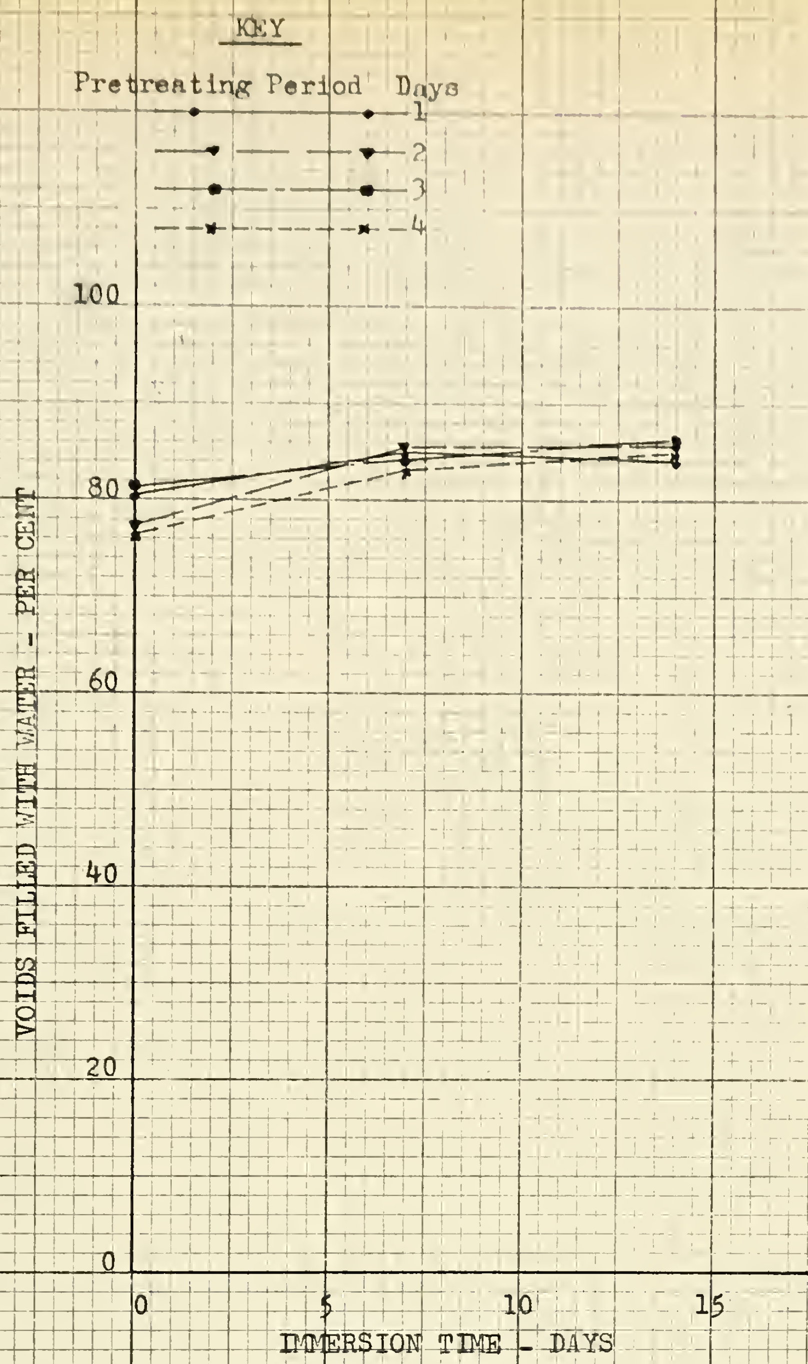


VOIDS FILLED WITH WATER-LIME-ASPHALT VS IMMERSION TIME

Standard Proctor Compactive Effort

ADDITIVE CONTENT:- 5% MC-3
5% LIME

FIGURE 6



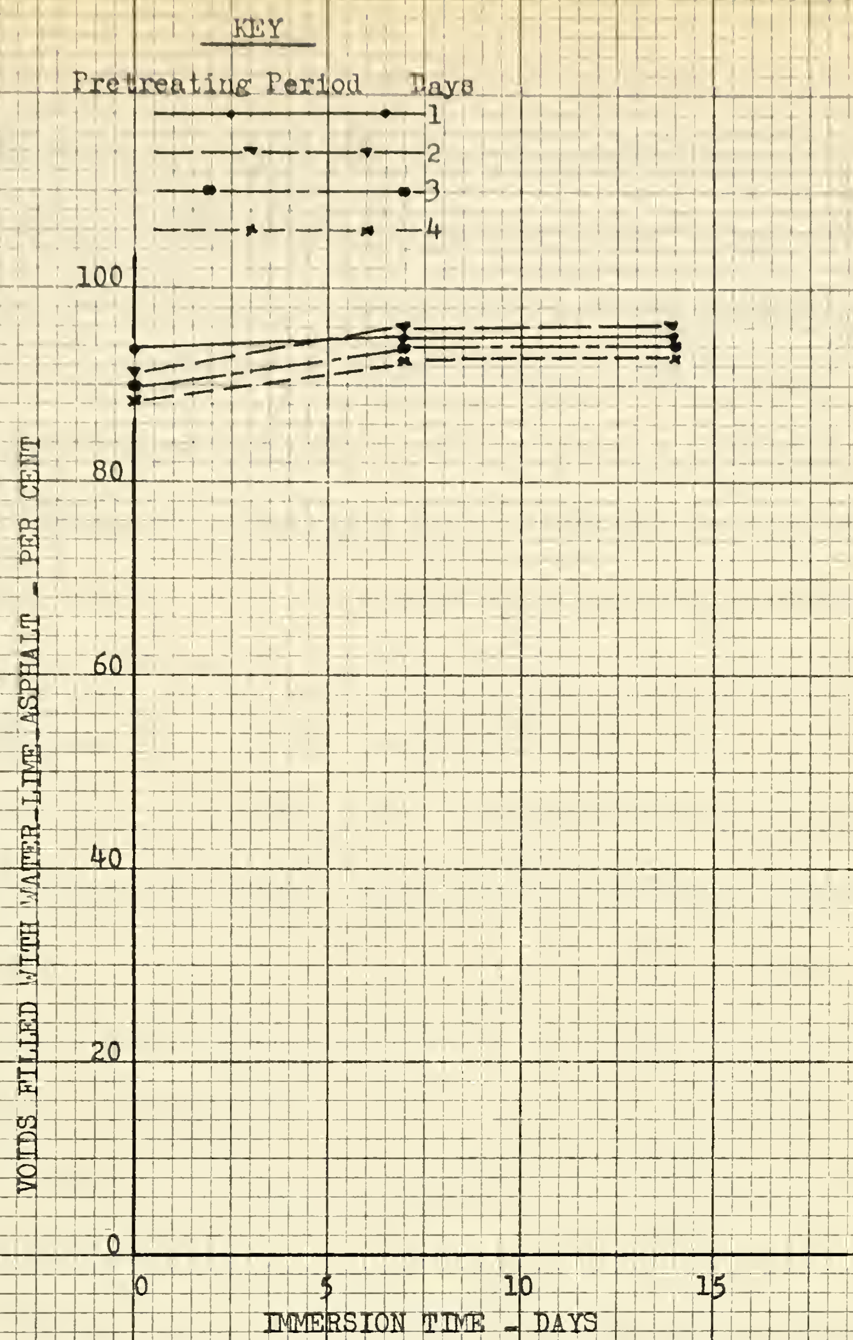
VOIDS FILLED WITH WATER VS IMMERSION TIME

Standard Proctor Compactive Effort

ADDITIVE CONTENT:- 3% MC-3

5% LIME

FIGURE 7



VOIDS FILLED WITH WATER-LIME-ASPHALT VS IMMERSION TIME

STandard Proctor Compactive Effort

ADDITIVE CONTENT:- 3% MC-3

5% LIME

FIGURE 8

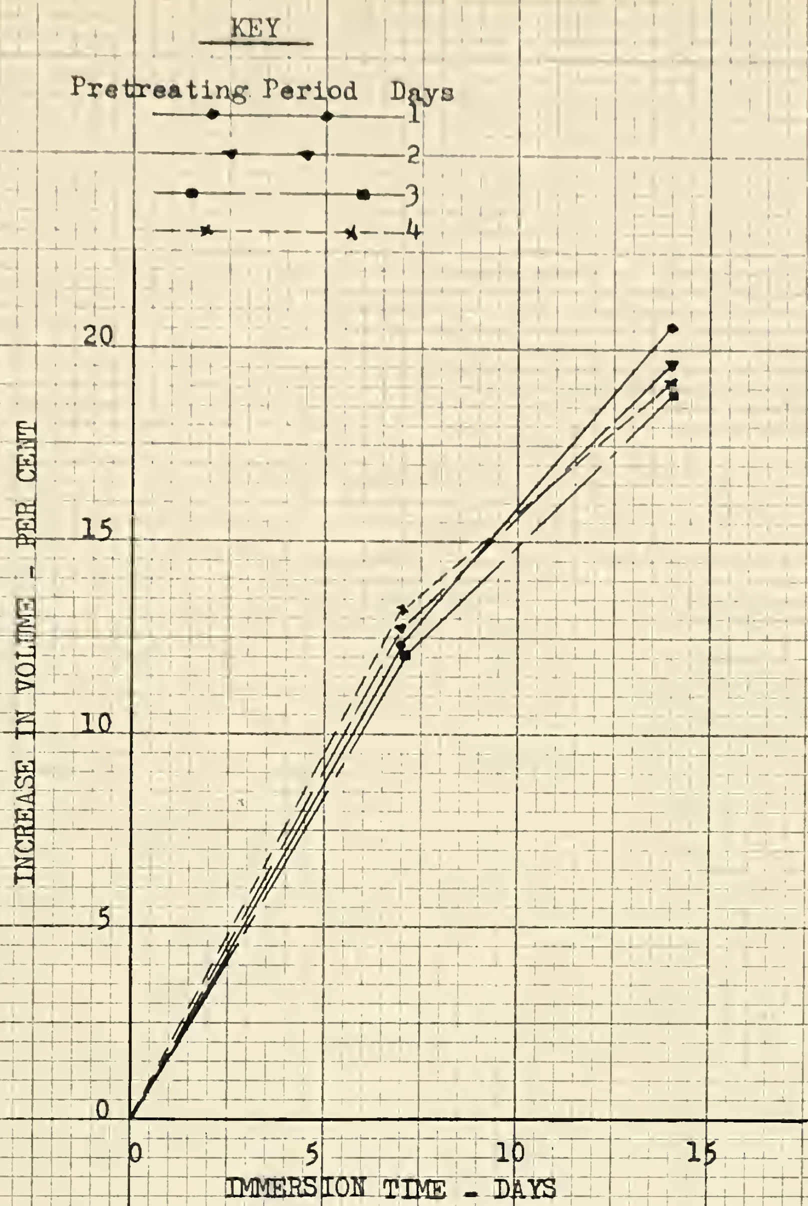
sorption, for specimens cured 7 days and 28 days at room temperature and immersed 24 hours, decreases when the asphalt content gradually increases. With the addition of 5 per cent asphalt in the mix, the percentage of water absorption is less than 1 per cent, after a curing period of 28 days. When only 3 per cent asphalt is added to the mix, the percentage of water absorption is more than 1.30 per cent.

TablesI and II also show that gradually increasing asphalt content in the mixture results in decreasing the amount of swelling. The percentage of increase in volume, for specimens cured 28 days at room temperature and immersed 24 hours, is 1.08 and 1.16 when 5 per cent and 3 per cent of asphalt is respectively used. Watt (1961) with the same clay and also the same mixture but without asphalt, reported that the increase in volume was in the order of 6.82 per cent, when specimens were soaked 24 hours after a curing period of 28 days in a moist room. Comparisons of these values demonstrate that the presence of asphalt in the mixture is beneficial and tends to reduce the specimen expansion.

Figures 9, 10, 12, and 13 give the percentage of water absorption and volumetric expansion for specimens immersed in water immediately after compaction. It is interesting to note that these figures show a slight decrease, during the first days of the immersion period, followed by an increase in the percentage of water absorption

and volumetric expansion in the mixture, with further immersion, caused by increasing asphalt content. These changes may be attributed to the presence of hydrated lime in the mixture, since Puzinauskas and Kallas (1961) mentioned that asphalt tends to retard the additive-soil reactions. Therefore, it is believed that, during the first days of immersion period, these reactions do not have the time to occur, but with further time of immersion, these reactions have the chance to take place. It is known that hydrated lime tends to reduce the volume changes that occur in soils. It is also believed that the speed of these reactions is related to the amount of asphalt in the mix. This, therefore, would explain the lower percentage of water absorption and volumetric expansion, at the end of the 14-day immersion period, for specimens containing 3 per cent asphalt.

These figures also show that the percentage of water absorption and volumetric expansion is quite high. However, it should be kept in mind that these specimens were not allowed to cure prior to immersion. Tables I and II indicate that a shorter curing period increases the percentage of water absorption and volumetric expansion. With the addition of 3 per cent asphalt to the mix, the percentage of water absorption and volumetric expansion is 2. 36 and 2. 10 respectively, after a curing period of 7 days. When the specimens are permitted to cured for 28 days these values are 1. 18 and 1. 12



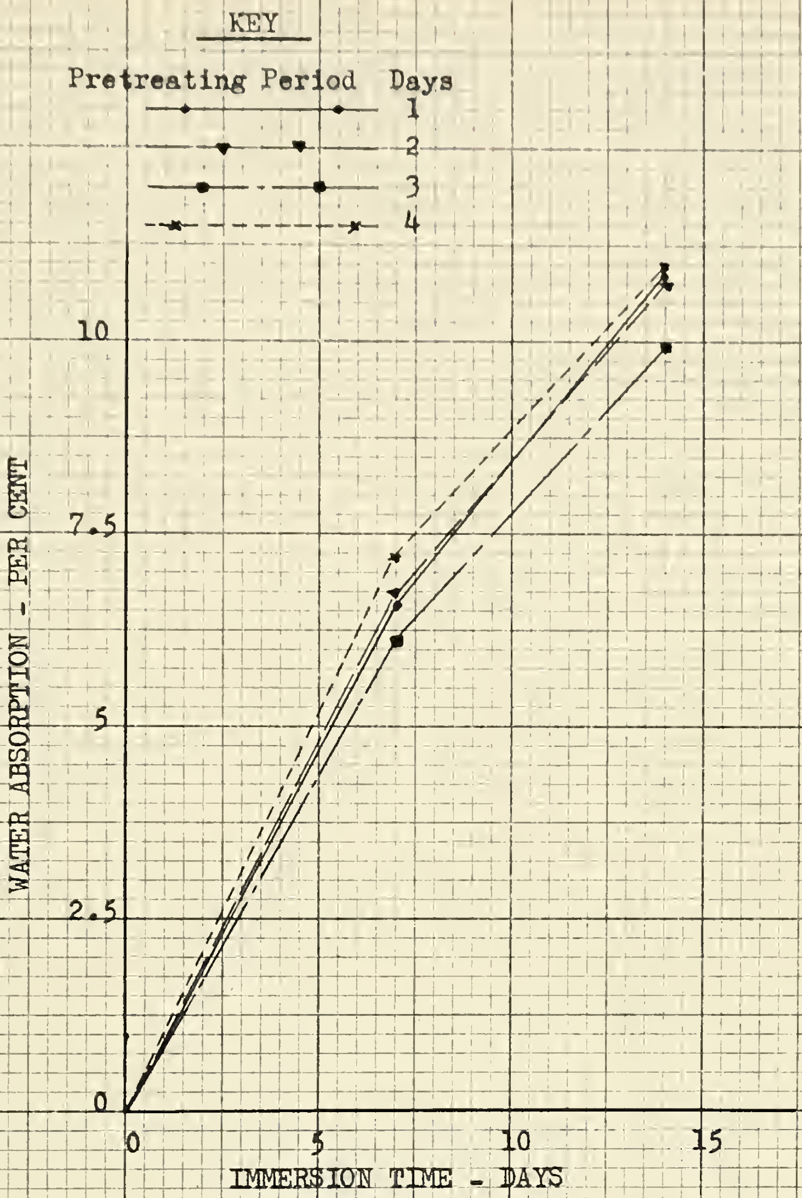
INCREASE IN VOLUME VS IMMERSION TIME

Standard Proctor Compactive Effort

ADDITIVE CONTENT:- 5% MC-3

5% LIME

FIGURE 9



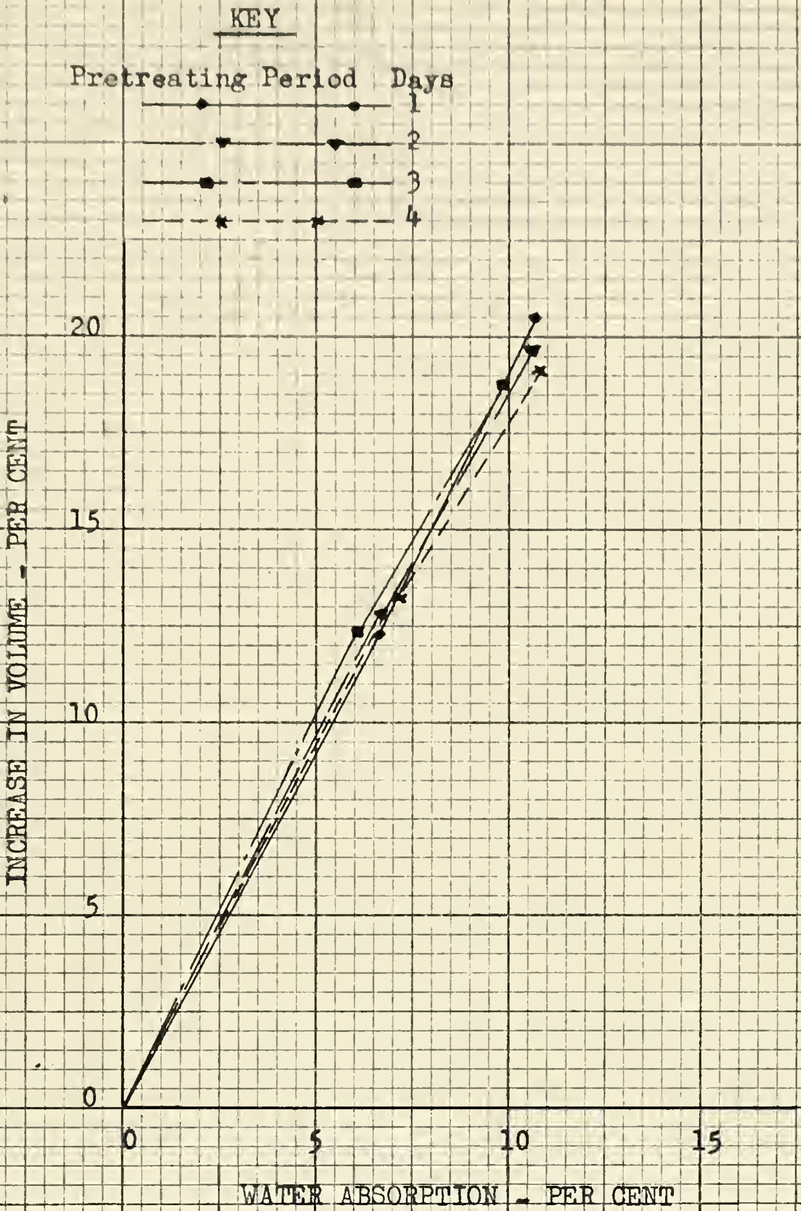
WATER ABSORPTION VS IMMERSION TIME

Standard Proctor Compactive Effort

ADDITIVE CONTENT:- 5% MC-3

5% LIME

FIGURE 10



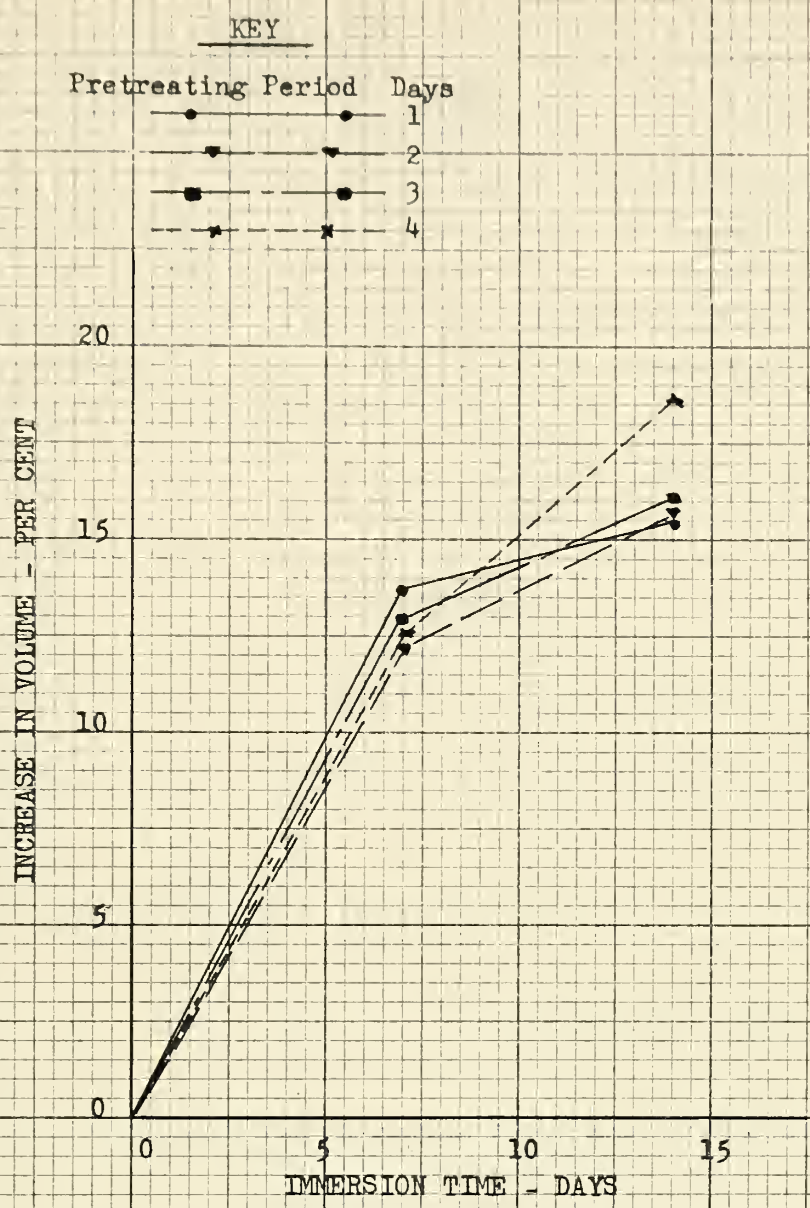
INCREASE IN VOLUME VS WATER ABSORPTION

Standard Proctor Compactive Effort

ADDITIVE CONTENT:- 5% MC-3

5% LIME

FIGURE 11



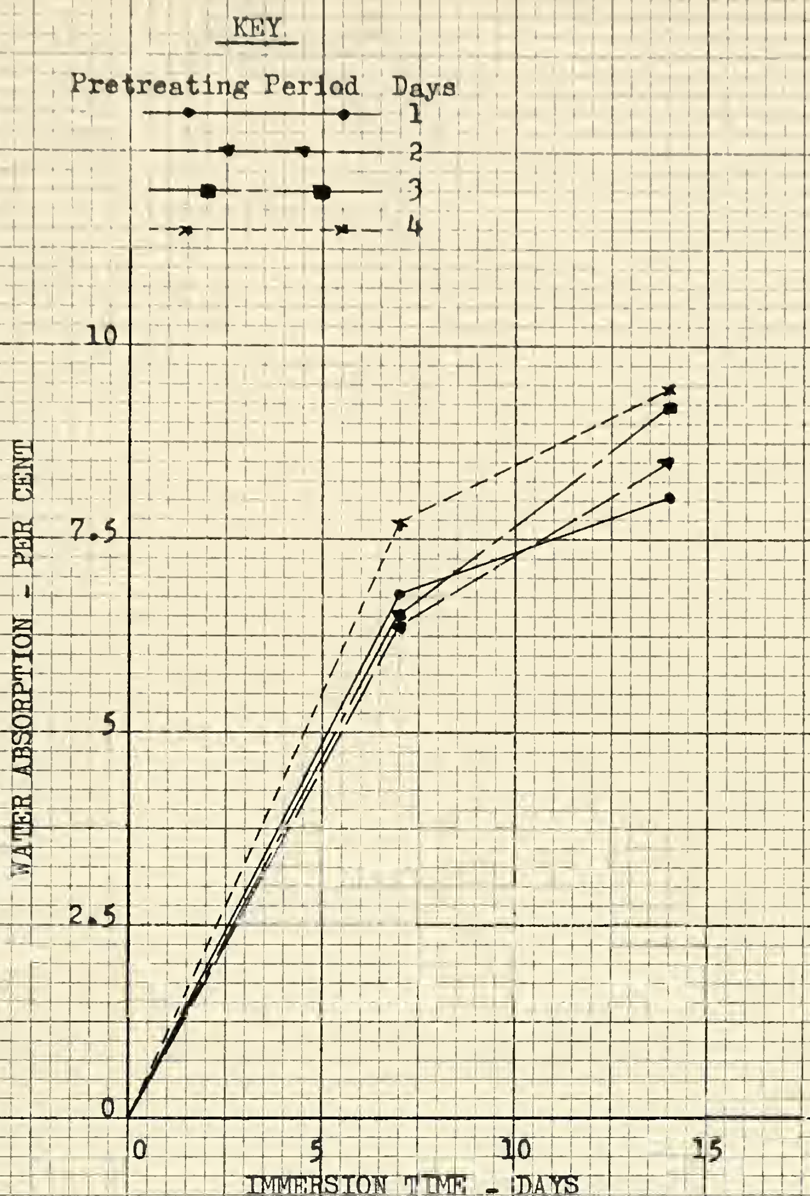
INCREASE IN VOLUME VS IMMERSION TIME

Standard Proctor Compactive Effort

ADDITIVE CONTENT:- 3% MC-3

5% LIME

FIGURE 12



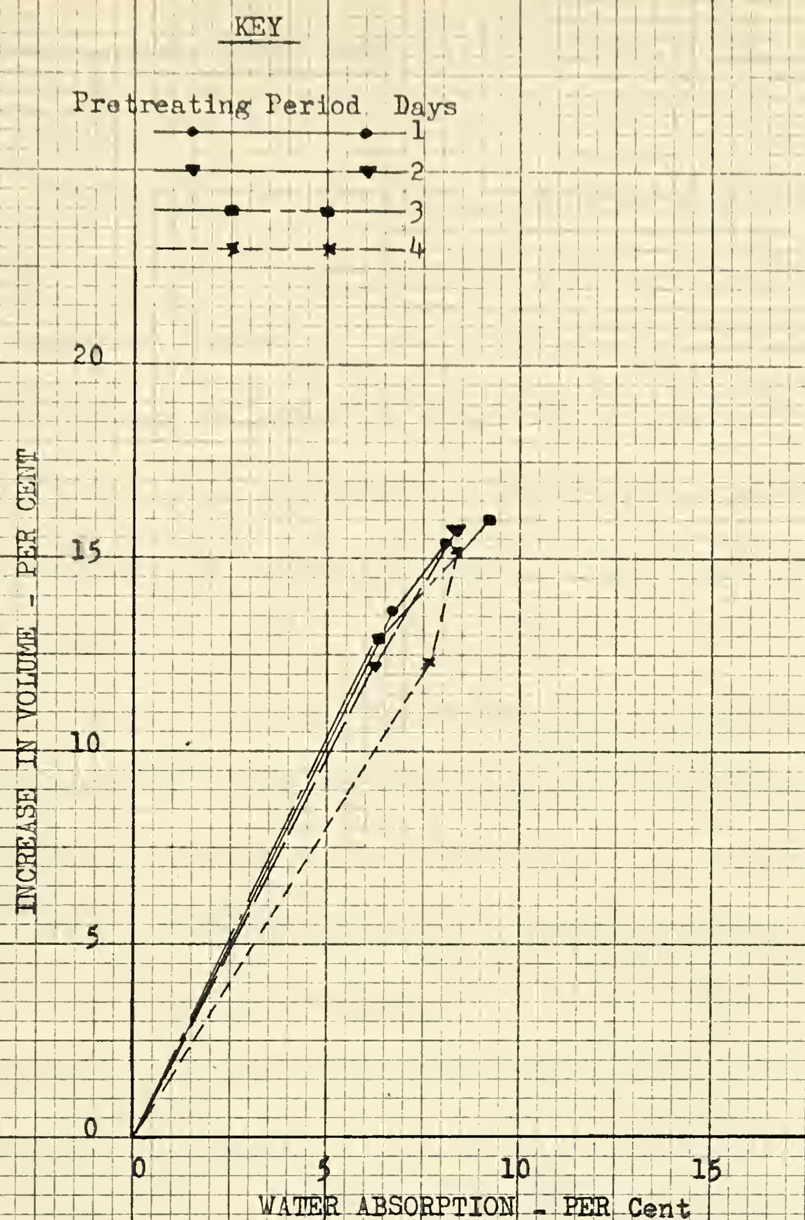
WATER ABSORPTION VS IMMERSION TIME

Standard Proctor Compactive Effort

ADDITIVE CONTENT:- 3% MC-3

5% LIME

FIGURE 13



INCREASE IN VOLUME VS WATER ABSORPTION

Standard Proctor Compactive Effort

ADDITIVE CONTENT:- 3% MC-3

5% LIME

FIGURE 14

respectively. It is evident that the percentage of water absorption and volumetric expansion is changed when the specimens are allowed to cure prior to immersion.

These high percentages of water absorption and swelling may have been influenced by the low asphalt contents used in this study (2.4 per cent and 4.0 per cent residual asphalt). In fact, if the asphalt content were not sufficient to plug the void spaces in the mix, this expansive clay would absorb water and swell quite rapidly. Different soils require different amounts of asphalt for most effective waterproofing.

Figures 11 and 14 give the relationship between the percentage of swelling and water absorption. It is interesting to note that this relationship is a straight line when 5 per cent asphalt is added to the mix. With the addition of 3 per cent asphalt to the mix, however, this straight line relationship is not so evident. The reason for such behavior was discussed previously and it was attributed to lime reactions.

It appears that the immersion test performed in this study was too severe. Specimens subjected to immersion should have probably been allowed to swell under a surcharge pressure comparable to that afforded by a typical pavement. It is believed that the percentage of swelling and water absorption, under such conditions would have been reduced markedly. (Herrin and Mitchell, 1961)

IV. 3 EFFECTS OF ROTTING PERIOD ON THE PROPERTIES OF CLAY-LIME-ASPHALT MIXTURES

Delays between mixing and compaction did help to break down clay clods and improve the mix uniformity. It appears, however, that changes caused by the action of lime to improve the final mixing are not so apparent after a 48-hour delay.

The results of the present investigation have shown that for the expansive clay soil studied, a delay between mixing and compaction is definitely detrimental in term of strength. Figures 1, 2, 3, and 4 show that a reduction of strength is caused by increasing delays between mixing and compaction. Figure 2 reveals that strengths decrease by as much as 16 per cent for a 4-day delay between mixing and compaction, for specimens cured 28 days at room temperature. This reduction of strength, as shown in figure 4, is more than 45 per cent for specimens immersed in water for 14 days.

The influence of delays on the density and the volumetric expansion is not so evident. Nevertheless, Tables I, II, III, and IV indicate that densities tend to decrease and volumetric expansions have a tendency to increase when delays increase between mixing and compaction.

Thus, on the basis of performance of samples, it might be concluded that a delay in compaction would be disadvantageous.

On the other hand, Mitchell and Hooper (1961) concluded that delay between mixing and compaction is not detrimental if extra compactive effort is provided to maintain the density.

In practice, the advantages of improved mix uniformity and handling characteristics that may result from allowing a delay between initial mixing and reworking prior to compaction may justify the expenditure of more compactive effort to obtain high density.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

The purpose of this investigation was given in chapter I, and was introduced by two questions:

1. Is the pretreatment with lime effective in reducing the plasticity of the highly plastic clay, thus making the clay more "workable"?

2. Is the addition of asphalt beneficial as a secondary additive in the stabilization of highly plastic clay modified with lime?

In the following conclusions, the answers to these questions are given.

V.1 CONCLUSIONS

The first question receives an affirmative reply without any doubt. Pretreating periods with lime, prior to compaction, reduce the plasticity of the clay and improve its handling characteristics. As mentioned in the literature survey, the plasticity index is influenced by the length of time the lime reacts with the soil. Test results support indications from the literature survey, that a delay between mixing and compaction is detrimental in terms of strength, density and swell, for specimens compacted with the same compactive effort.

It also appears from this study that changes caused by the action of lime to improve the workability of the clay are not so apparent after 48-hour delay.

An answer to the second question concerning benefits that can be derived from the conbined use of asphalt and lime in the stabilization of the highly plastic clay appears to be inconclusive. It is true that the presence of asphalt in the mix tends to reduce the strength and the density, but the principal function of asphalt, in such a mixture, is to waterproof the compacted soil mass. The results from this report indicated that the waterproofing characteristics, for specimens cured at room temperature during 28 days, were markedly improved by the addition of asphalt in the mixture. With the results from the immersion test, however, the waterproofing effects of asphalt were not so evident. This was assumed to be caused by the severity of the test.

On the basis of results presented in this study the general following conclusions are offered:

(1) The unconfined compressive strengths of clay-lime mixtures are markedly affected by the presence of asphalt. Asphalt decreases the strength of compacted mix.

(2) Systems containing asphalt are less affected by the variations in the compaction liquid content.

(3) Increasing asphalt content lowers the density and the compressive strength of the compacted specimen.

(4) The maximum strengths for the systems with or without asphalt are obtained at less than optimum liquid content.

(5) Optimum water content is lower when asphalt is present in the mixture.

(6) The strengths of specimens immersed in water for 7 and 14 days show no significant decrease with increasing immersion period.

(7) Waterproofing effects are improved by the use of more asphalt.

(8) Delays between mixing and compaction help to break down clay clods and improve the mix uniformity.

(9) Delays prior to compaction are detrimental in terms of strength, density and swell, for specimens compacted at the same compactive effort.

V.2 RECOMMENDATIONS

(1) Further sutdies should be made to determine the exact amount of asphalt require to waterproof this expansive clay treated with lime. In addition, durability tests should be performed to evaluate the effects of cold temperatures on these mixtures. It is also suggested that the water immersion test should be conducted with a

surcharge pressure applied on the specimen, during the immersion period.

(2) An evaluation of this highly plastic clay is not complete without a comparison of its effectiveness with cement. Additional investigations are needed to determine the behavior of cement with this highly plastic clay. The clay soil to be stabilized with cement should be pretreated with lime to flocculaté the soil particles and thus facilitate the mixing process.

(3) Investigators in the field of clay-lime stabilization claim that lime materially influences the swelling of soils. Basic research should be conducted to gain a more thorough knowledge of the effects of lime upon the swelling properties of this expansive clay.

BIBLIOGRAPHY

1. Anon, (1954), "Lime Stabilization of Roads," National Lime Assn., Washington, D.C.

2. A.S.T.M. (1958), "Procedures for Testing Soils," American Society for Testing Material, Philadelphia.

3. Cape, B.E., (1940), "Test Methods Used in the Design and Control of Soil-Bituminous Mixtures in Texas," Assn. of Asphalt Paving Technologists, Volume 12.

4. Clark, J.G., (1958), "Triaxial Shear Experiments on a Gravel Containing Portland Cement and Lime-Fly Ash Admixtures," Master of Science Thesis,[1] University of Alberta, Edmonton.

5. Eades, J.L. and Grim, R.E., (1961), "The Reaction of Hydrated Lime with Pure Clay Minerals in Soil Stabilization," H.R.B. Bull. No. 262.

6. Endersby, V.A., (1942), "Fundamental Research in Bituminous Soil Stabilization," H.R.B. Proceeding, Volume 22.

7. Harvey, T.S.W., (1960), "A Study of the Effects of Cyclic Freezing on a Clayey Gravel Stabilized with Additives and the Influence of these Additives on Permeability," Master of Science Thesis, University of Alberta, Edmonton.

8. Herrin, M., (1958), "Drying Phase of Soil-Asphalt Construction", H.R.B. bulletin 204.

9. Herrin, Moreland, and Mitchell Henry, (1961), "Lime-Soil Mixtures", H.R.B. bulletin 304.

10. Hilt, G.H., and Davidson, D.T., (1960), "Lime Fixation in Clayey Soils", H.R.B. bulletin 262.

11. Hvozdanski, J., (1962), "Lime Pozzolan Stabilization of a Clay", Master of Science Thesis, University of Alberta.

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[1] Referenced Master of Science Theses of University of Alberta are all unpublished.

12. Jones, V.C., (1962), "Durability Tests on an Asphalt Stabilized Sand", Master of Science Thesis, University of Alberta.

13. Katti, R.K., Davidson, D.T., and Sheeler, J.B., (1960), "Water in Cutback Asphalt Stabilization of Soil", H.R.B. bulletin 241.

14. Knowles, J.A., (1962), "Soil-Asphalt Stabilization with a Lime Additive", Master of Science Thesis, University of Alberta.

15. Lund, O.L., and Ramsey, W.J., (1959), "Experimental Lime Stabilization in Nebraska", H.R.B. bulletin 231.

16. Mateos, M., and Davidson, D.T., (1962), "Lime and Flyash Proportions in Soil, Lime and Flyash Mixtures and Some Aspects of Soil Lime Stabilization", Preprint for presentation at the forty first Annual Meeting of the H.R.B., Washington.

17. McDowell, C., (1953), "Road and Laboratory Experiments with Soil-Lime Stabilization", Proc., National Lime Assn.

18. McDowell, C., (1959), "Stabilization of Soils with Lime, Lime-Flyash, and other Lime Reactive Materials", H.R.B. bulletin 231.

19. Michaels, A.S., and Puzinauskas, V., (1958), "Improvement of Asphalt-Stabilized fine-grained Soils with Chemical Additives", H.R.B. bulletin 204.

20. Mitchell, J.K., and Hooper, D.R., (1961), "Influence of Time Between Mixing and Compaction on Properties of a Lime-Stabilized Expansive Clay", H.R.B. bulletin 304.

21. Pennell, G.D., (1962), "Structural Comparison of a Sand-Asphalt with a Soil-Cement", Master of Science Thesis, University of Alberta.

22. Pietsch, P.E., and Davidson, D.T., (1962), "Effects of Lime on Plasticity and Compressive Strength of Representative Iowa Soils", Preprint for presentation at the forty first Annual Meeting of the H.R.B., Washington.

23. Puzinauskas, V.P., and Kallas, B.F., (1961), "Stabilization of fine-grained Soils with Cutback Asphalt and Secondary Additives", H.R.B. bulletin 309.

24. Watt, G.W., (1961), "Lime Pozzolan Stabilization of Clay", Master of Science Thesis, University of Alberta.

25. Winterkorn, H.F., (1948), "Fundamental Approach to the Stabilization of Cohesive Soils, H.R.B. proceeding, Volume 28.

26. Winterkorn, H.F., and Dutta Choudhury, A.N., (1949), "Importance of Volume Relationships in Soil Stabilization, H.R.B. proceeding, Volume 29.

27. Winterkorn, H.F., (1957), "Granulometric and Volumetric Factors in Bituminous Soil Statilization", H.R.B. proceeding, Volume 36, pp. 773.

28. Woods, K.B., (1960), "Soil Stabilization", Highway Engineers Hand Book, section 21.

29. Yoder, E.J., (1959), "Principles of Pavement Design", John Wiley and Sons, Inc., New York.

APPENDICES

APPENDIX A

CLASSIFICATION TEST PROCEDURES

I. SPECIFIC GRAVITY

The following procedure was used to determine the specific gravity of the clay and the lime.

1. A 500 milliliter flask was calibrated to determine the weight of the flask filled with water at temperatures between 20C and 30C.

2. The clean, dry flask was weighed to the nearest 0.01 grams.

3. Approximately 50 grams of soil was placed in the flask and the weight of the air-dry soil in the glass was determined to the nearest 0.02 grams.

4. Approximately 250 milliliters of distilled water was added slowly to the flask and the soil was mixed into the water by gently shaking the flask.

5. The mixture was allowed to soak overnight and then was de-aired for twenty minutes under a vacuum of 0.95 kg per sq cm.

6. The vacuum was released at the completion of the de-aired procedure, and water was added until the level reached the neck of the bottle. Complete de-airing was checked by reapplying the

vacuum and watching for a significant rise in the water level. If the rise of the water level in the neck of the bottle was less than one-half inch, the de-airing was considered complete.

7. The flask was filled to the calibration mark with water and weighed to the nearest 0.01 grams.

8. The temperatures of the mixture was taken immediately after recording the weight of the flask filled with water and soil.

9. The weight of the flask filled with water was calculated from a calibration curve using the temperature obtained in 8.

10. Having determined the weight of soil, W_s; the weight of the flask filled with water and soil, W_{b+w+s}; the weight of the flask filled with water, W_{b+w}; the specific gravity was calculated form the equation:

$$G_s = \frac{W_s}{W_{b+w} + W_s - W_{b+w+s}}$$

II. THE ATTERBERG LIMITS

Liquid Limit

The procedure outlined in ASTM D423-54T, was used to determine the liquid limit except the soil was soaked overnight at approximately the liquid limit before the test was conducted.

Plastic Limit

The procedure outlined in ASTM D424-54T was followed to determine the plastic limit except the soil was soaked overnight at approximately the plastic limit before the test was conducted.

III. GRAIN SIZE ANALYSIS

A hydrometer analysis was used to determine the grain size distribution of the clay. The following detailed procedure was used in the test:

1. A moist specimen of soil, representing approximately 50 grams dry weight, was mixed with distilled water to form a smooth thin paste.

2. Twenty cc of 6%, by weight, solution of sodium hexametaphosphate was added to the paste as a dispersing agent.

3. The mixture was washed into a dispersion cup, and was stirred mechanically by a milk shake mixer for ten minutes.

4. The specimen, after mixing, was washed into a graduated cylinder and distilled water was added to bring the level of the solution to the 1000 cc mark.

5. The soil and water were mixed in the graduate by placing the palm of the hand over the open end and turning the graduate upside down. The graduate was rigorously shaken to loosen any soil that was stuck to the bottom of the graduate.

6. The mixing continued until the graduate has been inverted a total of thirty times. The graduate was then placed on a table and a timer was started.

7. Hydrometer readings were taken at total elapsed times of 1/4, 1/2, 1 and 2 minutes without removing the hydrometer.

8. The suspension was then remixed and the test was restarted with the first reading taken at 2 minutes; followed by readings at 4, 8, 15, 30 and 60 minutes and at approximately 2, 4, 8, 12 and 24 hours. The hydrometer was removed from the suspension after each reading.

9. After the final reading, the suspension was washed into an evaporating dish and the weight of the soil was determined by oven drying the specimen.

10. The hydrometer had been previously calibrated and a meniscus correction was added to each reading.

11. Corrections for the volume of the hydrometer were made for the readings that were two minutes and less.

12. The corrected readings were then used to find limiting diameters for the various elapsed times by means of a monograph, which had been previously calibrated for the hydrometer.

13. Meniscus, temperature, and density corrections were applied to the original readings and the resultant corrected readings were entered into the following equation:

$$W\% = \frac{100}{W_s} \cdot \frac{G_s}{G_s - 1} \cdot R_h$$

where G_s was the specific gravity of the soil

W_s was the weight of oven-dry soil in grams

R_h was the corrected hydrometer reading

and $W\%$ was the percentage of the total dry weight of soil finer than the limiting diameter, calculated in 12, for each elapsed time.

14. The results were plotted on a graph of log of diameter versus the per cent finer than each diameter.

15. The percentages of sand, silt and clay sizes were read directly from the graph.

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SPECIFIC GRAVITY

PROJECT Clay-Lime-Asphalt Stabilization	
SITE U of A	
SAMPLE Highly Plastic Clay	
LOCATION Fahler, Alberta	
HOLE	DEPTH
TECHNICIAN P.A.B.	DATE July 62

Sample No.	1	2
Flask No.	P.B.	A.B.
Method of Air Removal	Vacuum	Vacuum
W_{b+w+s}	700.22 gm.	725.67 gm.
Temperature T	22.8 °C	22.75°C
W_{b+w}	655.61 gm.	680.43 gm.
Evaporating Dish No.	8A	9A
Wt. Sample Dry + Dish	174.80 gm.	181.50 gm.
Tare Dish	104.91 gm.	110.59 gm.
W_s	69.89 gm.	70.91 gm.
G_s	2.76_6	2.77_2

W_{b+w+s} = Weight of flask + water + sample at T°.
W_{b+w} = Weight of flask + water at T° (flask calibration curve).
W_s = Weight of dry soil
G_s = Specific gravity of soil particles $= \dfrac{W_s}{W_s + W_{b+w} - W_{b+w+s}}$

Determination of W_s from wet soil sample:

Sample No.			Sample No.		
Container No.			Container No.		
Wt. Sample Wet + Tare			Wt. Test Sample Wet + Tare		
Wt. Sample Dry + Tare			Tare Container		
Wt. Water			Wt. Test Sample Wet		
Tare Container			W_s		
Wt. of Dry Soil					
Moisture Content w %					

Description of Sample: Highly plastic clay from Fahler, Alberta

Remarks: $G_s = 2.77$

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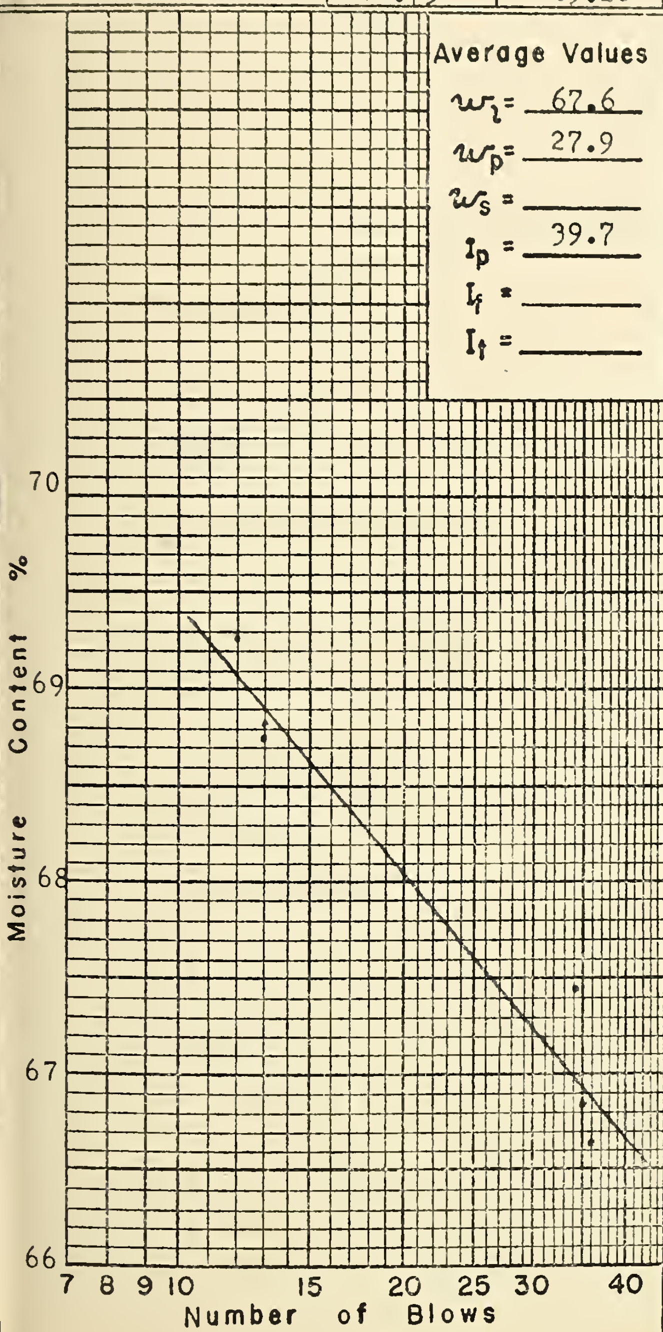
ATTERBERG LIMITS

PROJECT	Clay-Lime-Asphalt Stabilization
SITE	U of A
SAMPLE	Highly Plastic Clay
LOCATION	Fahler, Alberta
HOLE	DEPTH
TECHNICIAN P.A.B.	DATE July 62.

Liquid Limit

Trial No.	1	2	3	4	5	6
No. of Blows	13	12	13	35	36	34
Container No.	1	2	3	4	5	5a
Wt. Sample Wet + Tare	109.41	109.33	99.10	109.58	110.65	95.83
Wt. Sample Dry + Tare	100.33	99.32	90.20	99.97	100.15	86.36
Wt. Water	9.08	10.01	8.90	9.61	10.50	9.47
Tare Container	87.13	84.88	77.28	85.60	84.39	72.33
Wt. of Dry Soil	13.20	14.44	12.92	14.37	15.76	14.03
Moisture Content w%	68.75	69.26	68.80	66.85	66.65	67.45



Average Values

w_l = 67.6

w_p = 27.9

w_s =

I_p = 39.7

I_f =

I_t =

Plastic Limit

Trial No.	1	2	3
Container No.	7	8	9
Wt. Sample Wet+Tare	87.27	87.325	86.57
Wt. Sample Dry+Tare	86.21	85.80	84.94
Wt. Water	1.06	1.525	1.63
Tare Container	82.42	80.30	79.12
Wt. of Dry Soil	3.79	5.50	5.82
Moisture Content %	28.0	27.7	28.0

Shrinkage Limit

Trial No.			
Container No.			
Wt. Sample Wet + Tare			
Wt. Sample Dry + Tare			
Wt. Water			
Tare Container			
Wt. of Dry Soil W_o			
Moisture Content w%			
Vol. Container V			
Vol. Dry Soil Pat V_o			
Shrinkage Vol. $V-V_o$			
Shrinkage Limit w_s			

$$w_s = w - \left(\frac{V-V_o}{W_o} \times 100\right)$$

Description of Sample:

Highly Plastic Clay

Remarks:

The soil was soaked over night before running the test.

HYDROMETER TEST

Material	Limiting Diameter	Per cent
Sand sizes	greater than 0.06 mm	15%
Silt sizes	0.002 mm to 0.06 mm	30%
Clay sizes	less than 0.002 mm	55%

The soil was classified as a highly plastic clay (CH) under the Unified Soil Classification.

APPENDIX B

MOISTURE-DENSITY-STRENGTH RELATIONSHIPS

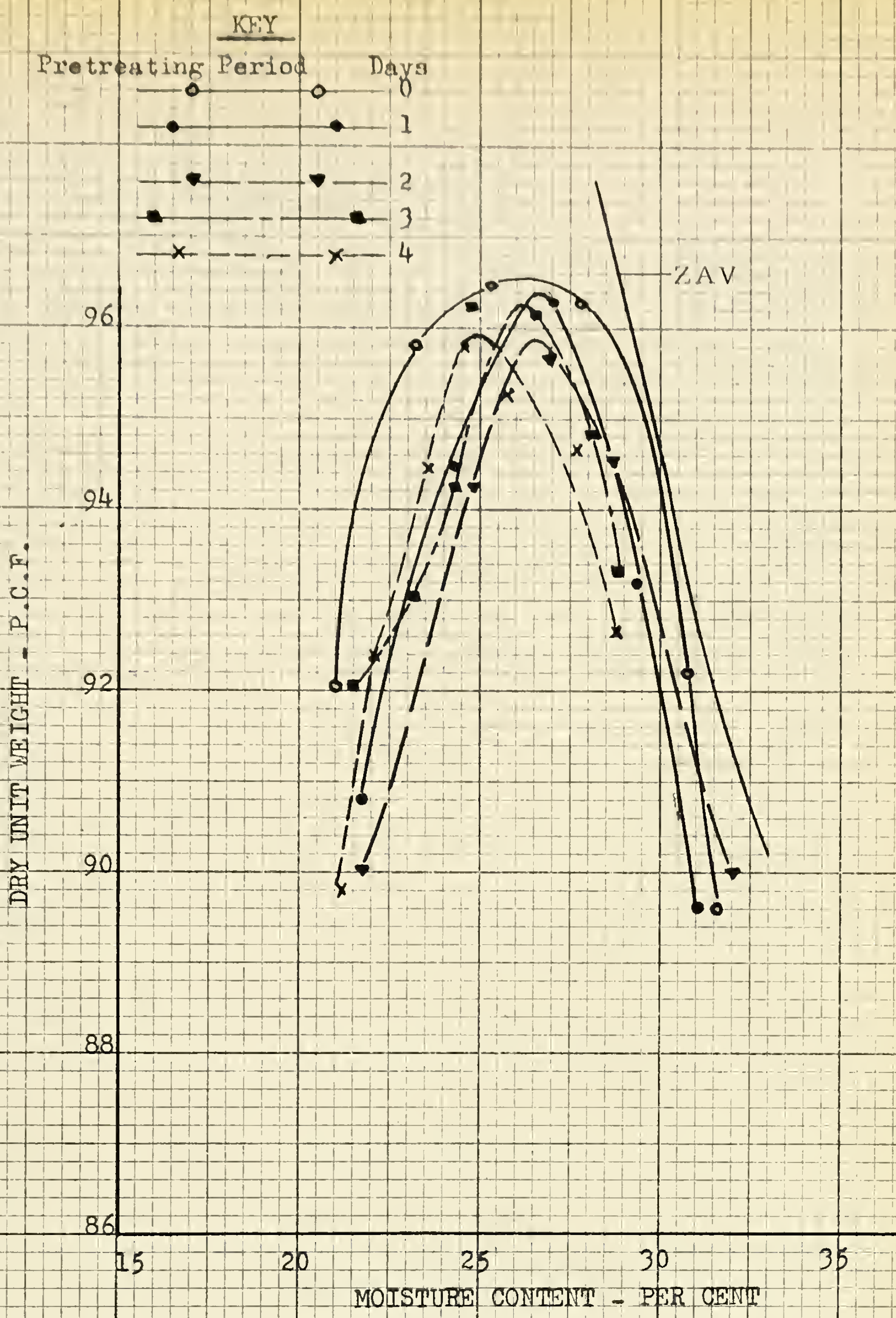
Moisture-density-strength curves were run using cylindrical 2-in. by 4-in. specimens prepared by compacting the specimens in four equal layers with a compactive effort of 10 blows per layer with the 5.5-lb. hammer, dropping a distance of 12 inches. The clay-lime mixtures were compacted after rotting periods ranging from zero to 4 days, while the clay-lime-asphalt mixtures were compacted after a 24-hour rotting period.

After the compaction, specimens were removed from the mold, were sealed in polyethylene bags and cured for 7 days at room temperature.

At the end of the curing period, specimens were removed from the bags, were measured and tested for unconfined compression strength using a Tinius Olsen Hydraulic Compression Testing Machine. Specimens were broken at a rate of strain ranging between 0.096 and 0.108 inches per minute.

Moisture-density and moisture-strength curves, for specimens containing 5 per cent of lime, are shown in figures 15 and 16 respectively.

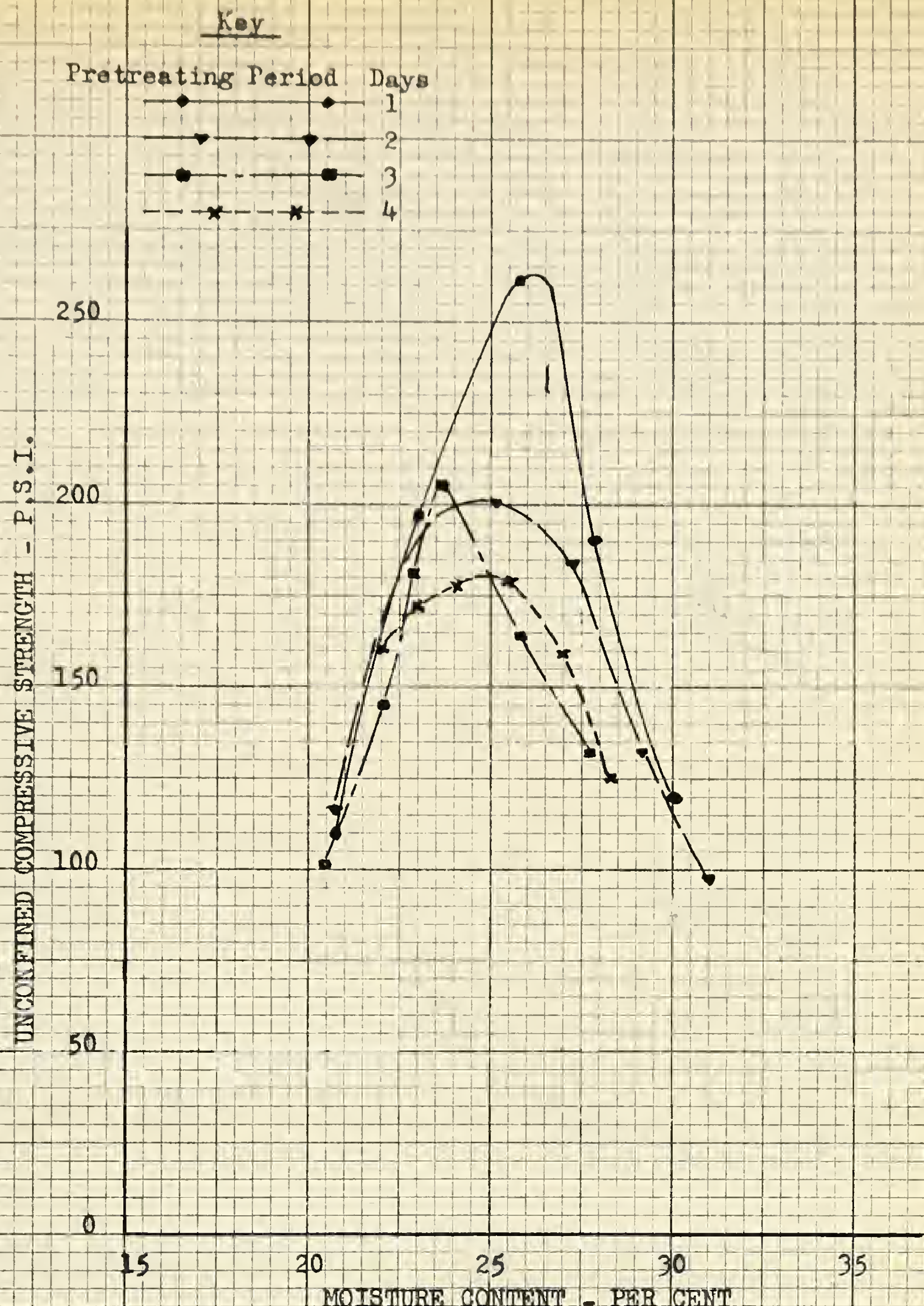
Figures 17 and 18 respectively show moisture-density and moisture-strength relationships for specimens containing 5 per cent of lime and 3 or 5 per cent of MC-3 asphalt.



DRY UNIT WEIGHT VS MOISTURE CONTENT

ADDITIVE CONTENT:- 5% LIME

FIGURE 15



UNCONFINED COMPRESSIVE STRENGTH VS MOISTURE CONTENT

Standard Proctor Compactive Effort

ADDITIVE CONTENT:- 5% LIME

FIGURE 16

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COMPACTION TEST

PROJECT	Clay-Lime-Asphalt Stabilization
SITE	U of A
SAMPLE	Highly Plastic Clay + Lime
LOCATION	Clay from Fahler
HOLE	DEPTH
TECHNICIAN P.A.B.	DATE July 62

	Trial Number	1	2	3	4	5	6	7
Unit Weight Determination	Mold No.	1	1	1	1	1	1	1
	Wt. Sample Wet + Mold	2586.5	2595.2	2603.9	2610.0	2594.5	2584.2	2603.3
	Wt. Mold	2209.0	2209.0	2209.0	2209.0	2209.0	2209.0	2209.0
	Wt. Sample Wet	377.5	386.2	394.9	401.0	385.5	375.2	394.3
	Volume Mold Ft^3	.0072	.0072	.0072	.0072	.0072	.0072	.0072
	Wet Unit Weight lb/ft^3	115.5	118.2	120.9	122.7	117.9	114.6	120.6
	Dry Unit Weight lb/ft^3	92.0	95.8	96.5	96.3	89.6	85.0	92.2
Moisture Content Determination	Container No.	1	2	3	4	5	6	7
	Wt. Sample Wet + Tare	159.35	150.96	161.44	158.19	163.51	140.90	171.61
	Wt. Sample Dry + Tare	146.78	138.47	144.50	142.56	144.49	123.25	150.61
	Wt. Water	12.57	12.49	16.94	15.63	19.02	17.65	21.00
	Tare Container	87.10	84.85	77.25	85.57	84.38	72.30	82.38
	Wt. Dry Soil	59.68	53.62	67.25	56.99	60.11	50.95	68.23
	Moisture Content	21.1	23.3	25.2	27.5	31.5	34.7	30.8

Max. Unit Wt. = 96.6 ft^3
Opt. Moist. = 25.7%

Unit Weight — lb/ft^3

Moisture Content %

Method of Compaction

Diam. Mold 2.00 in.
Height Mold 3.96 in.
Volume Mold .0072 ft^3
No. of Layers 4 layers
Blows per Layer 10
Ht. of Free Fall 12 in.
Wt. of Tamper 5.5 lb.
Shape of Tamping Face round
Description of Sample
Highly Plastic Clay with
5% Hydrated calcitic Lime

Remarks
Compaction immediately
after mixing.

Results plotted on master
graph.

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COMPACTION TEST

PROJECT	Clay-Lime-Asphalt Stabilization
SITE	U of A
SAMPLE	Fahler Clay + 5% Lime
LOCATION	
HOLE	DEPTH
TECHNICIAN P.A.B.	DATE July 62

		1	2	3	4	5	6	7
	Trial Number	1	2	3	4	5	6	7
Unit Weight Determination	Mold No.	2	2	2	2	2	2	2
	Wt. Sample Wet + Mold	2578.4	2601.3	2617.0	2611.5	2598.7	2600.8	2596.0
	Wt. Mold	2204.6	2204.6	2204.6	2204.6	2204.6	2204.6	2204.6
	Wt. Sample Wet	373.8	396.7	412.4	406.9	394.1	396.2	391.4
	Volume Mold	.00743	.00743	.00743	.00743	.00743	.00743	.00743
	Wet Unit Weight lb/ft^3	110.5	117.5	122.5	120.5	116.9	117.5	116.0
	Dry Unit Weight lb/ft^3	90.5	94.5	96.3	93.2	88.75	89.6	86.2
Moisture Content Determination	Container No.	1	2	3	4	5	6	7
	Wt. Sample Wet + Tare	151.35	152.91	134.82	155.78	162.62	156.63	139.18
	Wt. Sample Dry + Tare	139.89	139.62	122.51	139.92	143.74	136.56	124.54
	Wt. Water	11.46	13.29	12.31	15.86	18.88	20.07	14.64
	Tare Container	87.08	84.84	77.24	85.56	84.35	72.29	82.39
	Wt. Dry Soil	53.81	54.78	45.27	54.36	59.39	64.27	42.15
	Moisture Content	21.7	24.3	27.2	29.2	31.8	31.2.	34.8

Max. Unit Wt. = 96.7 ft^3
Opt. Moist. = 26.7%

Unit Weight – lb/ft^3

Moisture Content %

Method of Compaction ______

Diam. Mold 2.02 in.
Height Mold 4.0 in.
Volume Mold 0.00743 ft^3
No. of Layers 4
Blows per Layer 10
Ht. of Free Fall 12 in.
Wt. of Tamper 5.5 lb.
Shape of Tamping Face round
Description of Sample

Highly Plastic Clay with
5% Hydrated calcitic Lime

Remarks

Compaction 1 day after
Mixing.

Results plotted on master
graph.

UNIVERSITY of ALBERTA
DEP'T· of CIVIL ENGINEERING
SOIL MECHANICS LABORATORY
COMPACTION TEST

PROJECT	Clay-Lime-Asphalt Stabilization
SITE	U of A
SAMPLE	Fahler Clay + 5% lime
LOCATION	
HOLE	DEPTH
TECHNICIAN P.A.B.	DATE July 62.

	Trial Number	1	2	3	4	5	6	7
Unit Weight Determination	Mold No·	2	2	2	2	2	2	2
	Wt· Sample Wet + Mold	2573.7	2599.8	2612.8	2615.4	2604.4	2595.0	
	Wt· Mold	2204.4	2204.4	2204.4	2204.4	2204.4	2204.4	
	Wt· Sample Wet	369.3	395.4	408.4	410.7	400.0	390.6	
	Volume Mold	.00743	.00743	.00743	.00743	.00743	.00743	
	Wet Unit Weight lb·/ft^3	109.0	117.5	121.3	121.9	118.3	116.0	
	Dry Unit Weight lb·/ft^3	90.0	94.2	95.6	94.6	90.2	87.5	
Moisture Content Determination	Container No·	1	2	3	4	5	6	
	Wt· Sample Wet + Tare	177.32	162.48	154.68	155.38	140.43	146.13	
	Wt· Sample Dry + Tare	161.23	147.12	138.26	139.82	127.18	127.91	
	Wt· Water	16.09	15.36	16.42	15.56	13.25	18.22	
	Tare Container	87.09	84.86	77.26	85.58	84.26	72.30	
	Wt· Dry Soil	74.14	62.26	61.00	54.24	42.82	55.61	
	Moisture Content	21.7	24.7	26.9	28.7	30.9	32.8	

Max· Unit Wt·= 95.9/ft^3
Opt· Moist· = 26.6%

Unit Weight – lb·/ft^3

Moisture Content %

Method of Compaction

Diam· Mold 2.02 in.
Height Mold 4.0 in.
Volume Mold .00743 ft^3
No· of Layers 4
Blows per Layer 10
Ht· of Free Fall 12 in.
Wt· of Tamper 5.5 lb.
Shape of Tamping Face round
Description of Sample

Highly plastic clay with
5% Hydrated calcitic Lime

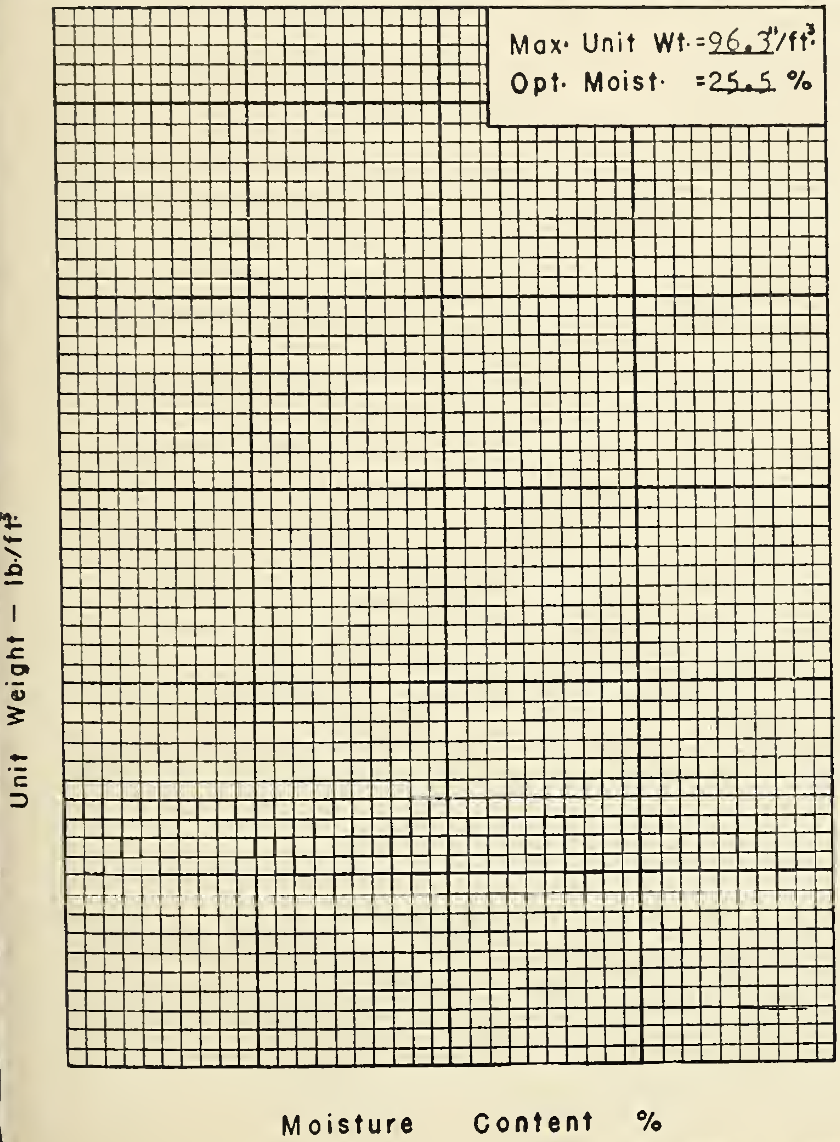
Remarks

Compaction 2 days after
Mixing

Results plotted on master
graph

UNIVERSITY of ALBERTA DEP'T· of CIVIL ENGINEERING SOIL MECHANICS LABORATORY **COMPACTION TEST**	
	PROJECT Clay-Lime-Asphalt Stabilization
	SITE U of A
	SAMPLE Fahler Clay + 5% Lime
	LOCATION
	HOLE DEPTH
	TECHNICIAN P.B. DATE July 62.

	Trial Number	1	2	3	4	5	6	7
Unit Weight Determination	Mold No·	2	2	2	2	2	2	2
	Wt· Sample Wet + Mold	2578.4	2590.9	2599.0	2609.5	2615.2	2614.5	2607.9
	Wt· Mold	2204.4	2204.4	2204.4	2204.4	2204.4	2204.4	2204.4
	Wt· Sample Wet	374.0	386.5	394.6	405.1	410.8	410.1	403.5
	Volume Mold	.00743	.00743	.00743	.00743	.00743	.00743	.00743
	Wet Unit Weight lb·/ft^3	112.3	114.5	117.0	120.0	121.6	121.5	120.2
	Dry Unit Weight lb·/ft^3	92.5	93.1	94.3	96.3	96.2	94.9	93.3
Moisture Content Determination	Container No·	1	2	3	4	5	6	7
	Wt· Sample Wet + Tare	164.75	153.34	156.12	157.51	159.72	151.81	145.54
	Wt· Sample Dry + Tare	151.11	140.47	140.78	143.28	143.96	134.40	131.41
	Wt· Water	13.64	12.87	15.34	14.23	15.76	17.41	14.13
	Tare Container	87.14	84.89	77.30	85.61	84.40	72.34	82.43
	Wt· Dry Soil	63.97	55.58	63.48	57.67	59.56	62.06	48.98
	Moisture Content	21.4	23.1	24.2	24.7	26.5	28.0	28.9



Method of Compaction

Diam. Mold 2.02 in.

Height Mold 4.00 in.

Volume Mold 0.00743 ft^3

No· of Layers 4

Blows per Layer 10

Ht· of Free Fall 12 in.

Wt· of Tamper 5.5 lb.

Shape of Tamping Face round

Description of Sample

Highly plastic clay with 5% Hydrated calcitic Lime

Remarks

Compaction 3 days after mixing.

Results plotted on master graph.

UNIVERSITY of ALBERTA
DEP'T. of CIVIL ENGINEERING
SOIL MECHANICS LABORATORY

COMPACTION TEST

PROJECT Clay-Lime-Asphalt Stabilization
SITE U of A
SAMPLE Fahler Clay + 5% Lime
LOCATION
HOLE DEPTH
TECHNICIAN P.B. DATE July 62.

	Trial Number	1	2	3	4	5	6	7
Unit Weight Determination	Mold No.	2	2	2	2	2	2	2
	Wt. Sample Wet + Mold	2572.2	2586.0	2598.1	2606.9	2607.1	2611.8	2606.8
	Wt. Mold	2204.4	2204.4	2204.4	2204.4	2204.4	2204.4	2204.4
	Wt. Sample Wet	367.8	381.6	393.7	402.5	402.7	407.4	402.4
	Volume Mold	.00743	.00743	.00743	.00743	.00743	.00743	.00743
	Wet Unit Weight lb/ft^3	108.8	112.9	116.6	119.4	119.5	120.8	119.5
	Dry Unit Weight lb/ft^3	89.8	92.4	94.5	95.8	95.3	94.7	92.7
Moisture Content Determination	Container No.	1	2	3	4	5	6	7
	Wt. Sample Wet + Tare	179.31	192.07	150.18	168.49	159.88	158.03	163.70
	Wt. Sample Dry + Tare	163.21	172.61	136.30	152.10	144.39	139.43	145.48
	Wt. Water	16.10	17.96	13.88	16.39	15.49	18.60	18.22
	Tare Container	87.13	84.89	77.28	85.60	84.39	72.32	82.42
	Wt. Dry Soil	76.08	87.72	59.02	66.50	60.00	67.11	63.06
	Moisture Content	21.2	22.2	23.5	24.6	25.8	27.7	28.9

Max. Unit Wt. = 95.8"/ft^3
Opt. Moist. = 24.8 %

Unit Weight — lb/ft^3

Moisture Content %

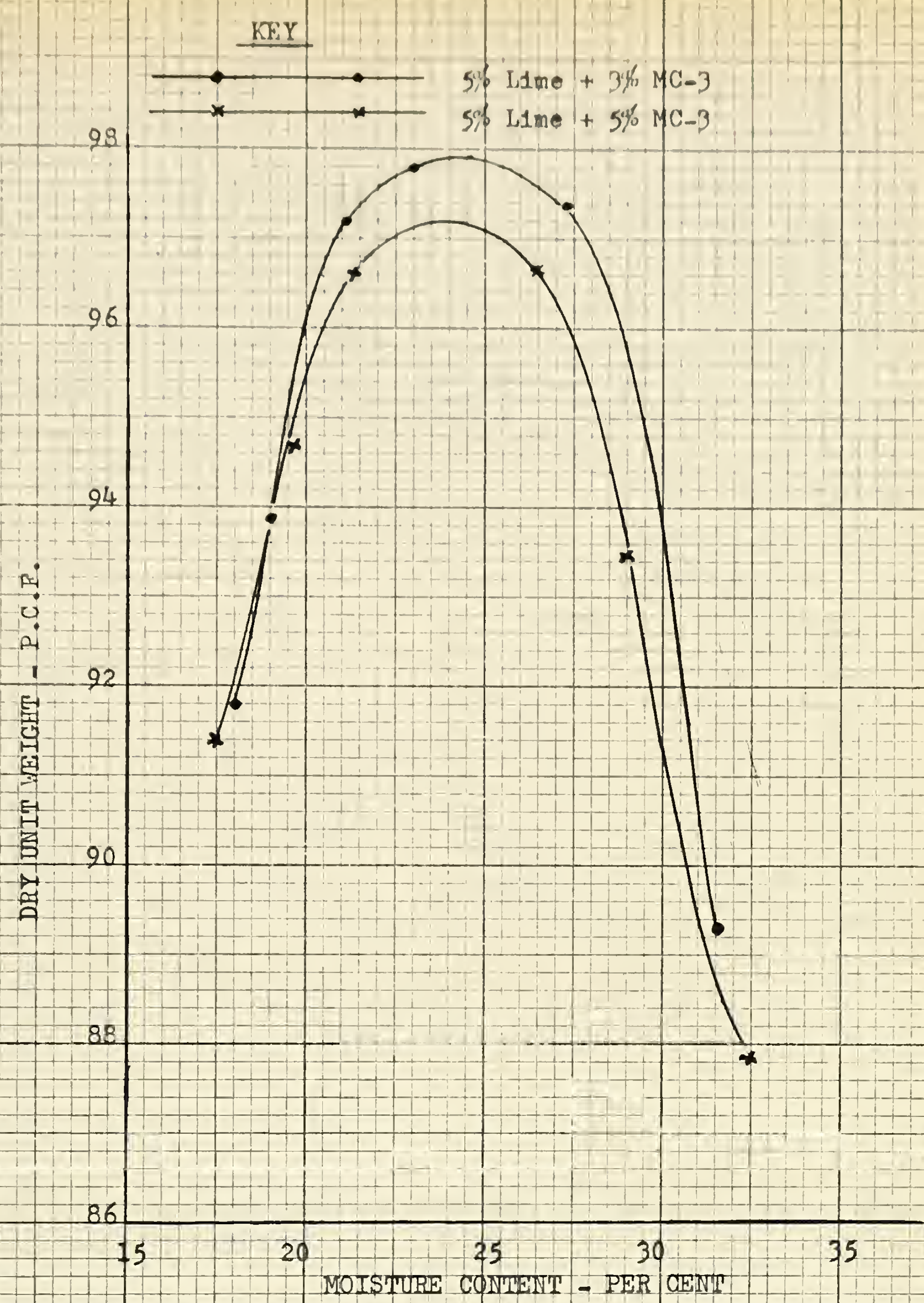
Method of Compaction

Diam. Mold 2.02 in.
Height Mold 4.00 in.
Volume Mold 0.00743 ft^3
No. of Layers 4
Blows per Layer 10
Ht. of Free Fall 12 in.
Wt. of Tamper 5.5 lbs.
Shape of Tamping Face round
Description of Sample

Highly plastic clay with
5% Hydrated calcitic Lime

Remarks
Compaction 4 days after
mixing.

Results plotted on master
graph



DRY UNIT WEIGHT VS MOISTURE CONTENT

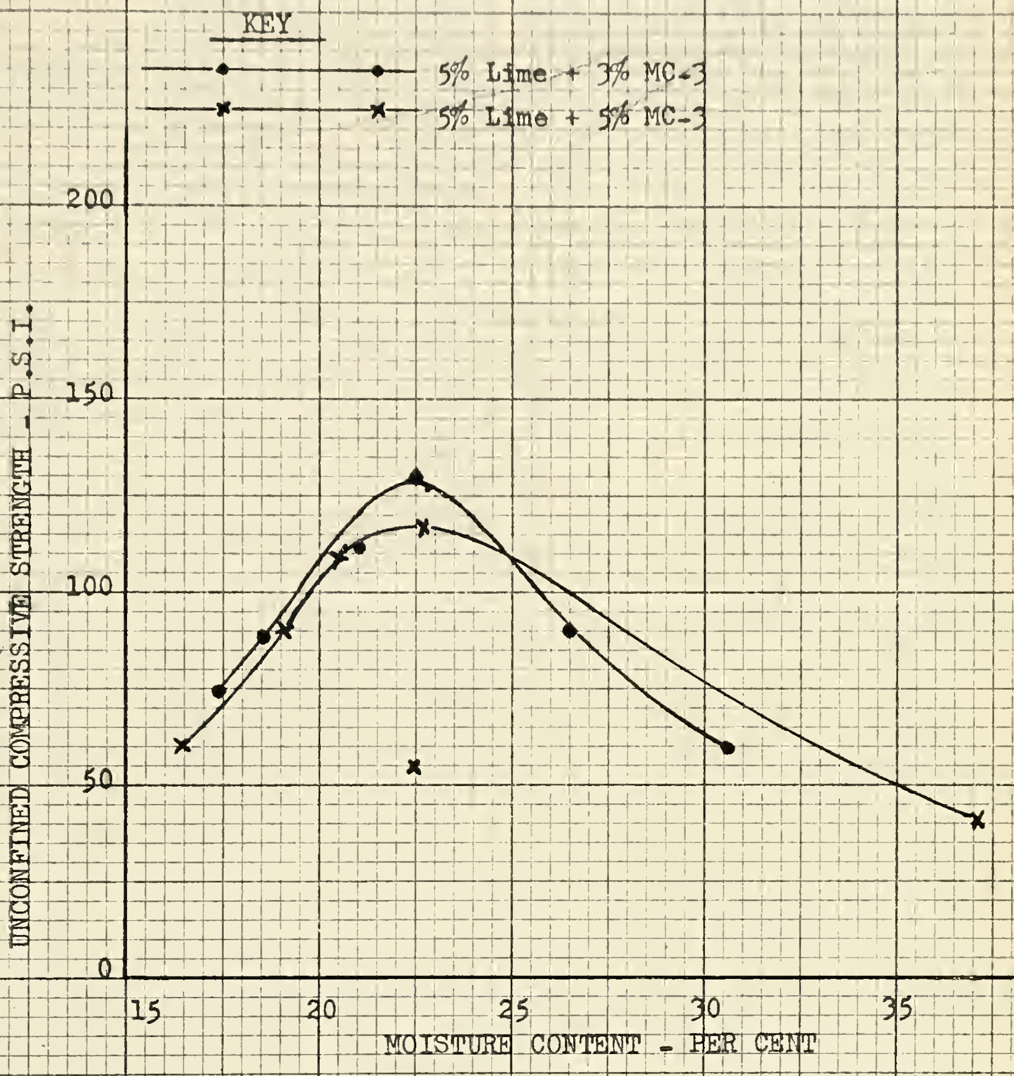
Standard Proctor Compactive Effort

ADDITIVE CONTENT:- 5% Lime + 3% MC-3

5% Lime + 5% MC-3

Pretreating Period 24 Hours

FIGURE 17



UNCONFINED COMPRESSIVE STRENGTH VS MOISTURE CONTENT

Standard Proctor Compactive Effort

Pretreating Period 24 Hours

FIGURE 18

UNIVERSITY of ALBERTA
DEP'T· of CIVIL ENGINEERING
SOIL MECHANICS LABORATORY
COMPACTION TEST

PROJECT Clay-Lime-Asphalt Stabilization
SITE U of A
SAMPLE Fahler clay +5% lime + 3% MC3
LOCATION
HOLE DEPTH
TECHNICIAN P.A.B. DATE July 62.

	Trial Number	1	2	3	4	5	6	
Unit Weight Determination	Mold No·	2	2	2	2	1	1	
	Wt· Sample Wet + Mold	2565.3	2577.5	2597.1	2604.1	2607.0	2590.7	
	Wt· Mold	2200.0	2200.0	2200.0	2200.0	2203.0	2203.0	
	Wt· Sample Wet	365.3	377.5	397.1	404.1	404.0	382.7	
	Volume Mold	.00743	.00743	.00743	.00743	.00743	.0072	
	Wet Unit Weight lb/ft^3	108.3	111.9	117.8	120.0	123.9	117.2	
	Dry Unit Weight lb/ft^3	91.8	93.9	97.2	97.8	97.4	89.3	
Moisture Content Determination	Container No·	1	2	3	4	5	6	
	Wt· Sample Wet + Tare	148.09	147.88	158.00	151.73	140.53	139.62	
	Wt· Sample Dry + Tare	137.74	137.74	145.21	139.22	128.51	125.12	
	Wt· Water	10.35	10.14	12.79	12.51	12.02	14.50	
	Tare Container	80.29	84.42	84.68	84.36	84.48	79.15	
	Wt· Dry Soil	57.45	53.32	60.53	54.86	44.03	45.97	
	Moisture Content	18.0	19.0	21.1	22.9	27.3	31.6	

Max· Unit Wt· = 97.9 lb/ft^3
Opt· Moist· = 24.5 %

Unit Weight — lb/ft^3

Moisture Content %

Method of Compaction

	2.00	2.02 in.
Diam. Mold	Mold-1	Mold-2
Height Mold	3.96	4.00 in.
Volume Mold	·0072	.00743 ft^3.

No· of Layers 4
Blows per Layer 10
Ht· of Free Fall 12 in.
Wt· of Tamper 5.5 lb.
Shape of Tamping Face round
Description of Sample

Highly plastic clay + 3% asphalt + 5% lime

Remarks

Compaction 1 day after mixing

Results plotted on master graph

Asphalt added prior to compaction.

UNIVERSITY of ALBERTA
DEP'T of CIVIL ENGINEERING
SOIL MECHANICS LABORATORY

COMPACTION TEST

PROJECT Clay-lime-asphalt Stabilization
SITE U of A
SAMPLE Fahler clay + 5% lime + 5% MC3
LOCATION
HOLE DEPTH
TECHNICIAN P.B. DATE July 62.

Trial Number	1	2	3	4	5	6	
Unit Weight Determination							
Mold No.	2	2	2	2	1	1	
Wt. Sample Wet + Mold	2563.9	2582.0	2594.8	2612.6	2596.8	2583.0	
Wt. Mold	2200.0	2200.0	2200.0	2200.0	2203.0	2203.0	
Wt. Sample Wet	363.9	382.0	394.8	412.6	393.8	380.0	
Volume Mold	.00743	.00743	.00743	.00743	.0072	.0072	
Wet Unit Weight lb/ft^3	107.5	113.2	117.0	122.3	120.5	116.3	
Dry Unit Weight lb/ft^3	91.4	94.7	96.6	96.7	93.5	87.9	
Moisture Content Determination							
Container No.	1	2	3	4	5	6	
Wt. Sample Wet + Tare	148.64	127.28	143.19	142.11	145.74	145.33	
Wt. Sample Dry + Tare	139.07	119.74	131.66	129.77	131.53	129.39	
Wt. Water	9.57	7.54	11.53	12.34	14.21	15.94	
Tare Container	84.49	81.35	77.42	83.15	82.44	80.32	
Wt. Dry Soil	54.58	31.39	54.24	46.62	49.09	49.07	
Moisture Content	17.5	19.7	21.3	26.5	29.0	32.5	

Max. Unit Wt. = 97.6 lb/ft^3
Opt. Moist. = 24.0 %

Unit Weight — lb/ft^3

Moisture Content %

Method of Compaction

	Mold-1	Mold-2
Diam. Mold	2.00	2.02 in.
Height Mold	3.96	4.00 in.
Volume Mold	.0072	.00743 ft^3

No. of Layers 4
Blows per Layer 10
Ht. of Free Fall 12 in.
Wt. of Tamper 5.5 lb.
Shape of Tamping Face round
Description of Sample

Highly plastic clay + 5% lime + 5% asphalt

Remarks
Compaction 1 day after mixing

Results plotted on master graph.

Asphalt added prior to compaction.

APPENDIX C

LIME-FLYASH STABILIZATION OF FINE GRAINED SOIL

Originally it was thought that lime-flyash stabilized soils might develop higher compressive strength than lime-pozzolan-soil mixtures.

Hutchinson [1] performed a quantitative comparison on four different types of pozzolans, and he found that the pozzolan from Diamond City exhibited the highest strength.

In this study, in order to determine the effectiveness of several pozzolanic materials, the Diamond City Shale is compared with two types of flyashes.

MATERIALS

The source and supplier of the pozzolan and flyashes are given in Table I.

TABLE I - SOURCE OF THE POZZOLAN AND FLYASHES.

	SOURCE	SUPPLIER
Pozzolan No. A	Diamond City	Western Minerals Ltd.
Flyash No. B	Forrestberg	Halliburton Oil Well Cementing Co.
Flyash No. C	Drumheller	" " " "

---

[1] Internal report of the Research Council of Alberta, Highways Division.

The chemical constituents of the pozzolan and flyashes are given in Table II. The chemical analysis of the pozzolan was supplied by Western Minerals Ltd., while the analysis of flyashes B and C were performed by Halliburton Oil Well Cementing Co.

TABLE II - CHEMICAL PROPERTIES OF THE POZZOLAN AND FLYASHES

Chemical Constituents (% by wt.)

	A	B	C
Silica	61.98	48.5	54.77
Alumina	20.41	21.6	19.47
Iron Oxide	4.91	6.5	7.79
Calcium Oxide	2.60	14.6	7.70
Magnesium Oxide	2.50	1.9	1.51
Sodium Oxide	0.68	-	-
Potassium Oxide	0.12	-	-
Undetermined	4.08	-	-
Sulphur Trioxide	-	Trace	.16
Loss on Ignition	2.82	4.8	5.45

Table III shows the chemical analysis of the hydrated lime. The hydrated calcitic lime was supplied from Loders Lime (Alberta) Limited. The chemical analysis of the lime was performed by the manufacturer.

TABLE III - CHEMICAL PROPERTIES OF LIME

Chemical Constituents (% by wt.)

Calcium Oxide	74.8
Magnesium Oxide	1.2
Iron Oxide, Aluminum Oxide	0.4
Silica	0.3
Loss on Ignition	22.9

Table IV indicates the source and type of soil used with the lime, pozzolan or flyashes.

TABLE IV - SOIL TYPE

	TYPE	SOURCE
Soil No. 1	Highly plastic clay	Fahler
Soil No. 2	Medium-fine sand	Hennig Pit

LABORATORY PROGRAM

The laboratory program was the one used by Hutchinson in its investigation.

Cylindrical 2-in. by 4-in. specimens of each mixture were prepared by compacting the specimens in four equal layers with a compactive effort of 10 blows per layer of the standard compaction hammer (5.5-lb. and 12-in. drop).

A 15% admixture of each pozzolan and calcitic hydrated lime by weight of the dry soil, with a weight ratio of pozzolan to lime of 2:1, was added to the following soil water mixture:

A. Soil 1 plus 25% water by weight of dry soil

B. Soil 2 plus 17% water by weight of dry soil

These moisture conditions represent closely the optimum water requirements of the compaction procedure used; a compactive effort of 10 blows per layer for the 2-in. x 4-in. cylindrical sample achieves a density about equal to the standard compaction test (Standard Proctor).

[illegible]

A replication of six specimens was used for each test, and the samples were sealed in polythene bags and cured at room temperature for periods of 7 and 28 days. After the curing period, the samples were measured and tested by means of the Tinius Olsen Hydraulic Testing Machine. The unconfined compressive strength of the specimens were computed using the corrected area. The average compressive strength of each mixture is shown in Table V.

TABLE V - COMPRESSIVE STRENGTH RESULTS

	POZZOLAN		FLYASHES			
	A		B		C	
SOIL TYPE	7 days psi	28 days psi	7 days psi	28 days psi	7 days psi	28 days psi
1	171	278	169	234	164	217
2	29	40	26	23	20	22

On the basis of the compressive strength results, the pozzolan "A" exhibited higher strength than the two types of flyashes.

[illegible]

APPENDIX D

METHOD OF CALCULATING VOID PROPERTIES

The following method of calculating the void properties of the specimens will offer an explanation of some of the terms used in the body of this report.

(1) Weight of Materials Added =

$$= \text{Dry Sample Weight} - \frac{\text{Dry sample Weight}}{1 + A\%} \times 100$$

where:

A = Total percentage of materials added

$= B + C$

B = Per cent of asphalt added

C = Per cent of lime added

(2) Weight of Soil Solids =

= Weight of Wet Sample - Weight of Additives

(3) Weight of Water =

= Weight of Wet Sample - Weight of Dry Sample

(4) Volume of Soil Solids =

$$= \frac{\text{Dry Sample Weight} - \text{Weight of Additives}}{\text{Specific Gravity of Soil Solids}}$$

(5) Volume of Voids =

= Volume of Sample - Volume of Soil Solids

(6) Per Cent Voids Filled with Asphalt =

$$= \frac{\dfrac{\text{Weight of Asphalt}}{\text{Specific Gravity of Asphalt}}}{\text{Volume of Voids}} \times 100$$

(7) Per Cent Voids Filled with Lime =

$$= \frac{\dfrac{\text{Weight of Lime}}{\text{Specific Gravity of Lime}}}{\text{Volume of Voids}} \times 100$$

(8) Per Cent Voids Filled with Water =

$$= \frac{\dfrac{\text{Weight of Water}}{\text{Specific Gravity of Water}}}{\text{Volume of Voids}} \times 100$$

(9) Total Void as Per Cent of Total Mix =

$$= \frac{\text{Volume of Voids}}{\text{Total Volume of Sample}} \times 100$$

APPENDIX E

SUMMARY OF DATA SHEETS

University of Alberta

CLAY-LIME-ASPHALT STABILIZATION

Pretreating Period 1 days		Test No.	1 - 6
Optimum Moisture Content (Clay-Lime Mixtures)	26.7 %	Percent Additive	10
Mix Design		Date Constructed	July 10
Wt. Lime (5 %)	117.5 gm.	Date Broken	July 18
Wt. Asphalt (5 %)	117.5 gm.	Curing Period 7	days
Wt. Soil + 6 % H_2O	2500.0 gm.	Soaking Period 1	day
Wt. Water	475.0 gm.	Immersion Period	days
Moulding Moisture Content		**Results**	
Container No.	1	Aver. Dry Unit Wt. - pcf	92.8
Wt. Wet Soil + Tare	136.87 gm.	Aver. Unconf. Load - lbs.	163.53
Wt. Dry Soil + Tare	125.19 gm.	Aver. Unconf. Press. - psi	50.3
Wt. Moisture	11.68 gm.	Aver. Soaked Moist. - %	24.78
Wt. Tare	77.50 gm.	Aver. Water Absorption - %	0.35
Wt. Dry Soil	47.69 gm.	Aver. Swelling - %	
Moisture Content	24.5 %		

Sample No:	51A1	51A2	51A3	51A4	51A5	51A6
Sample Height - inch	4.050	4.075	3.962	4.052	4.067	4.058
Wt. Wet Sample - gm.	391.8	391.9	379.0	387.0	391.3	386.0
Dry Unit Wt. - pcf	93.5	93.0	92.5	92.4	93.2	92.0
Unconf. Load - lbs.	176.0	151.8	160.6	169.4	165.0	158.4
Unconf. Press. - psi	54.2	46.5	49.3	52.2	50.8	48.8
Tare No:	1	2	3	4	5	6
Wt. Wet Soil + Tare	436.03	433.96	422.10	432.78	435.24	430.35
Wt. Dry Soil + Tare	357.98	356.62	346.85	355.85	357.73	354.52
Wt. Moisture	78.05	77.34	75.25	76.93	77.51	75.83
Wt. Tare	44.92	44.40	43.35	45.65	44.60	45.10
Wt. Dry Soil	313.06	312.22	303.50	310.20	313.13	309.42
Soaked Moist. Cont. %	25.0	24.8	24.9	24.8	24.7	24.5

University of Alberta

CLAY-LIME-ASPHALT STABILIZATION

Pretreating Period	1 days	Test No.	7 - 12
Optimum Moisture Content (Clay-Lime Mixtures)	20.[illegible] %	Percent Additive	10
Mix Design		Date Constructed	July 10
Wt. Lime (5 %)	117.5 gm.	Date Broken	August [illegible]
Wt. Asphalt (5 %)	117.5 gm.	Curing Period	28 days
Wt. Soil + 6 % H_2O	2500.0 gm.	Soaking Period	1 day
Wt. Water	175.0 gm.	Immersion Period	days
Moulding Moisture Content		**Results**	
Container No.	2	Aver. Dry Unit Wt. - pcf	92.4
Wt. Wet Soil + Tare	158.97 gm.	Aver. Unconf. Load - lbs.	206.61
Wt. Dry Soil + Tare	144.24 gm.	Aver. Unconf. Press. - psi	63.5
Wt. Moisture	14.73 gm.	Aver. Soaked Moist. - %	25.5
Wt. Tare	84.40 gm.	Aver. Water Absorption - %	1.16
Wt. Dry Soil	59.84 gm.	Aver. Swelling - %	1.08
Moisture Content	24.7 %		

Sample No:	51A7	51A8	51A9	51A10	51A11	51A12
Sample Height - inch	4.007	4.007	4.020	4.005	4.003	3.986
Wt. Wet Sample - gm.	382.08	383.15	383.87	382.72	381.29	380.29
Dry Unit Wt. - pcf	92.6	92.6	92.3	92.4	92.2	92.3
Unconf. Load - lbs.	190.3	209.0	220.0	217.8	193.6	209.0
Unconf. Press. - psi	58.9	64.5	67.9	67.2	59.5	63.2
Tare No:	1b	2b	3b	4b	5b	6b
Wt. Wet Soil + Tare	599.02	613.35	612.01	602.63	631.50	601.01
Wt. Dry Soil + Tare	523.27	536.21	532.35	524.46	552.81	524.38
Wt. Moisture	75.75	77.14	79.66	78.17	81.69	76.63
Wt. Tare	213.81	228.00	224.87	216.39	250.34	217.65
Wt. Dry Soil	309.46	308.21	307.48	308.07	302.47	306.73
Soaked Moist. Cont. %	25.0	25.1	25.8	25.3	26.9	25.0

University of Alberta

CLAY-LIME-ASPHALT STABILIZATION

Pretreating Period [illegible] days		Test No.	[illegible]
Optimum Moisture Content (Clay-Lime Mixtures)	[illegible] %	Percent Additive	[illegible]
Mix Design		Date Constructed	July 11
Wt. Lime ([illegible] %)	117.5 gm.	Date Broken	July 1[illegible]
Wt. Asphalt (5 %)	117.5 gm.	Curing Period 7	days
Wt. Soil + 6 % H_2O	[illegible] gm.	Soaking Period 1	day
Wt. Water	[illegible] gm.	Immersion Period ___	days
Moulding Moisture Content		**Results**	
Container No.	134	Aver. Dry Unit Wt. - pcf	[illegible]
Wt. Wet Soil + Tare	[illegible] gm.	Aver. Unconf. Load - lbs.	[illegible].33
Wt. Dry Soil + Tare	[illegible] gm.	Aver. Unconf. Press. - psi	[illegible]
Wt. Moisture	[illegible].57 gm.	Aver. Soaked Moist. - %	26.7
Wt. Tare	79.[illegible]1 gm.	Aver. Water Absorption - %	0.49
Wt. Dry Soil	[illegible].67 gm.	Aver. Swelling - %	
Moisture Content	24.3 %		

Sample No:	5[illegible]A13	52A14	52A15	52A16	52[illegible]17	5[illegible]18
Sample Height - inch	[illegible].021	4.[illegible]1	4.016	4.00[illegible]	4.0[illegible]	4.[illegible]8
Wt. Wet Sample - gm.	[illegible]3.7	[illegible]4.1	37[illegible].0	374.5	376.0	37[illegible].5
Dry Unit Wt. - pcf	90.5	90.8	90.4	91.3	91.[illegible]	91.6
Unconf. Load - lbs.	92.4	88.0	92.4	9[illegible].4	110.0	96.8
Unconf. Press. - psi	28.6	27.1	28.5	[illegible]8.7	34.1	[illegible].1
Tare No:	1	2	3	4	5	6
Wt. Wet Soil + Tare	416.98	417.27	[illegible]14.19	418.62	419.31	[illegible]19.92
Wt. Dry Soil + Tare	[illegible]8.12	338.40	335.42	340.25	340.[illegible]	340.8[illegible]
Wt. Moisture	78.36	78.87	78.77	78.37	[illegible].63	7[illegible].4
Wt. Tare	44.92	4[illegible].40	[illegible].35	45.65	44.60	4[illegible].10
Wt. Dry Soil	293.70	[illegible]4.00	29[illegible].07	[illegible]94.60	296.08	[illegible].7[illegible]
Soaked Moist. Cont. %	26.7	26.8	[illegible].0	26.6	2[illegible].5	[illegible].7

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CLAY-LIME-ASPHALT STABILIZATION

Pretreating Period	[illegible] days	Test No.	[illegible]
Optimum Moisture Content (Clay-Lime Mixtures)	[illegible] %	Percent Additive	10
Mix Design		Date Constructed	July 11
Wt. Lime (5 %)	[illegible] gm.	Date Broken	August 9
Wt. Asphalt (5 %)	[illegible] gm.	Curing Period	28 days
Wt. Soil + 6 % H_2O	2500.0 gm.	Soaking Period	1 day
Wt. Water	175.0 gm.	Immersion Period	___ days
Moulding Moisture Content		**Results**	
Container No.	[illegible]	Aver. Dry Unit Wt. - pcf	92.6
Wt. Wet Soil + Tare	[illegible] gm.	Aver. Unconf. Load - lbs.	[illegible]
Wt. Dry Soil + Tare	[illegible] gm.	Aver. Unconf. Press. - psi	47.5
Wt. Moisture	[illegible] gm.	Aver. Soaked Moist. - %	[illegible]
Wt. Tare	[illegible] gm.	Aver. Water Absorption - %	0.59
Wt. Dry Soil	[illegible] gm.	Aver. Swelling - %	0.64
Moisture Content	[illegible] %		

Sample No:	52A19	[illegible]	52A21	52A22	52A23	52A24
Sample Height - inch	4.008	[illegible]	4.001	4.003	4.015	4.029
Wt. Wet Sample - gm.	374.6	[illegible]	374.5	386.6	386.8	387.4
Dry Unit Wt. - pcf	91.8	[illegible]	91.8	[illegible]	93.5	[illegible]
Unconf. Load - lbs.	[illegible]	107.5	123.2	[illegible]	[illegible]	[illegible]
Unconf. Press. - psi	[illegible]	33.5	[illegible]	57.2	[illegible]	[illegible]
Tare No:	7a	8a	9a	10a	11a	12a
Wt. Wet Soil + Tare	[illegible]	[illegible]	479.?5	421.44	486.28	491.52
Wt. Dry Soil + Tare	[illegible]	[illegible]	[illegible]	[illegible]	413.42	[illegible]
Wt. Moisture	75.?	[illegible]	[illegible]	[illegible]	72.96	[illegible]
Wt. Tare	[illegible]	[illegible]	110.64	45.09	100.49	104.91
Wt. Dry Soil	[illegible]	295.89	296.62	[illegible]	312.93	[illegible]
Soaked Moist. Cont. %	25.7	[illegible]	[illegible]	[illegible]	23.3	[illegible]

CLAY-LIME-ASPHALT STABILIZATION

Pretreating Period [illegible] days

Optimum Moisture Content (Clay-Lime Mixtures) [illegible] %

Mix Design

Wt. Lime ([illegible] %) 117.[illegible] gm.

Wt. Asphalt (5 %) [illegible] gm.

Wt. Soil + [illegible] % H_2O [illegible] gm.

Wt. Water [illegible] gm.

Moulding Moisture Content

Container No. [illegible]

Wt. Wet Soil + Tare [illegible] gm.

Wt. Dry Soil + Tare [illegible] gm.

Wt. Moisture [illegible] gm.

Wt. Tare 84.88 gm.

Wt. Dry Soil 47.40 gm.

Moisture Content 23.7 %

Test No. [illegible]

Percent Additive [illegible]

Date Constructed [illegible]

Date Broken [illegible]

Curing Period [illegible] days

Soaking Period 1 day

Immersion Period ____ days

Results

Aver. Dry Unit Wt. - pcf [illegible]

Aver. Unconf. Load - lbs. 110.[illegible]

Aver. Unconf. Press. - psi [illegible]

Aver. Soaked Moist. - % [illegible]

Aver. Water Absorption - % [illegible]

Aver. Swelling - % ____

Sample No:	53425	534[illegible]	53[illegible]27	53[illegible]	534[illegible]	53[illegible]
Sample Height - inch	4.019	4.0[illegible]	[illegible]	[illegible].018	4.00[illegible]	4.0[illegible]
Wt. Wet Sample - gm.	[illegible]	[illegible]25.0	[illegible]	[illegible]	384.[illegible]	[illegible]4.0
Dry Unit Wt. - pcf	93.9	93.[illegible]	93.0	93.[illegible]	93.[illegible]	93.5
Unconf. Load - lbs.	101.2	107.8	107.3	11[illegible].[illegible]	10[illegible].8	1[illegible]
Unconf. Press. - psi	31.6	33.[illegible]	3[illegible].7	[illegible].5	[illegible]	38.5
Tare No:	1c	2c	3c	4c	5c	6c
Wt. Wet Soil + Tare	[illegible]31.17	428.10	425.33	429.8[illegible]	427.0[illegible]	427.10
Wt. Dry Soil + Tare	[illegible]	352.92	349.72	353.5[illegible]	351.07	351.[illegible]
Wt. Moisture	76.21	75.18	75.61	76.[illegible]	75.[illegible]	75.56
Wt. Tare	44.94	44.40	43.35	45.65	44.60	45.10
Wt. Dry Soil	[illegible]	308.5[illegible]	306.[illegible]	[illegible]	[illegible].47	[illegible]
Soaked Moist. Cont. %	[illegible]	24.[illegible]	[illegible].7	24.75	24.3	[illegible].7

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CLAY-LIME-ASPHALT STABILIZATION

Pretreating Period	3 days	Test No.		[illegible]
Optimum Moisture Content (Clay-Lime Mixtures)	[illegible] %	Percent Additive		10
Mix Design		Date Constructed		[illegible]
Wt. Lime (5 %)	112.5 gm.	Date Broken		July [illegible]
Wt. Asphalt (5 %)	112.5 gm.	Curing Period	7	days
Wt. Soil + 0 % H_2O	2500.0 gm.	Soaking Period	1	day
Wt. Water	[illegible] gm.	Immersion Period		days
Moulding Moisture Content		**Results**		
Container No.	3c	Aver. Dry Unit Wt. - pcf		[illegible]
Wt. Wet Soil + Tare	[illegible] gm.	Aver. Unconf. Load - lbs.		[illegible]
Wt. Dry Soil + Tare	[illegible] gm.	Aver. Unconf. Press. - psi		[illegible]
Wt. Moisture	11.25 gm.	Aver. Soaked Moist. - %		[illegible]
Wt. Tare	84.88 gm.	Aver. Water Absorption - %		[illegible]
Wt. Dry Soil	47.40 gm.	Aver. Swelling - %		
Moisture Content	[illegible] %			

Sample No:	53A25	53A26	[illegible]	53A28	53A29	53A30
Sample Height - inch	4.019	4.019	4.024	4.018	4.006	[illegible]
Wt. Wet Sample - gm.	387.0	385.0	[illegible]	385.6	[illegible]	[illegible]
Dry Unit Wt. - pcf	[illegible]	93.4	[illegible]	[illegible]	93.4	93.5
Unconf. Load - lbs.	101.2	107.8	107.8	116.6	[illegible]	[illegible]
Unconf. Press. - psi	31.6	33.6	[illegible]	36.5	[illegible]	38.5
Tare No:	1c	2c	3c	4c	5c	6c
Wt. Wet Soil + Tare	431.17	428.10	[illegible]	429.80	[illegible]	[illegible]
Wt. Dry Soil + Tare	354.96	[illegible]	[illegible]	353.56	[illegible]	[illegible]
Wt. Moisture	76.31	75.18	[illegible]	76.24	[illegible]	[illegible]
Wt. Tare	44.94	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Wt. Dry Soil	310.02	[illegible]	306.27	[illegible]	[illegible]	[illegible]
Soaked Moist. Cont. %	24.6	24.4	24.7	24.75	24.8	[illegible]

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CLAY-LIME-ASPHALT STABILIZATION

Pretreating Period	3 days	Test No.	31-36
Optimum Moisture Content (Clay-Lime Mixtures)	26.5 %	Percent Additive	10
Mix Design		Date Constructed	July 1
Wt. Lime (5 %)	117.5 gm.	Date Broken	August 1[illegible]
Wt. Asphalt (5 %)	117.5 gm.	Curing Period	28 days
Wt. Soil + 6 % H_2O	2500.0 gm.	Soaking Period	1 day
Wt. Water	475.0 gm.	Immersion Period	____ days
Moulding Moisture Content		**Results**	
Container No.	1c	Aver. Dry Unit Wt. - pcf	93.[illegible]
Wt. Wet Soil + Tare	118.91 gm.	Aver. Unconf. Load - lbs.	137.6
Wt. Dry Soil + Tare	108.83 gm.	Aver. Unconf. Press. - psi	42.[illegible]
Wt. Moisture	10.08 gm.	Aver. Soaked Moist. - %	23.55
Wt. Tare	67.25 gm.	Aver. Water Absorption - %	0.68
Wt. Dry Soil	41.58 gm.	Aver. Swelling - %	.35
Moisture Content	24.2 %		

Sample No:	53A31	53A32	53A33	53A34	53A35	53A36
Sample Height - inch	3.990	4.005	4.010	4.018	4.012	4.017
Wt. Wet Sample - gm.	383.0	385.0	385.0	385.0	386.0	385.5
Dry Unit Wt. - pcf	93.4	93.4	93.1	93.0	93.3	93.1
Unconf. Load - lbs.	146.3	138.6	138.6	130.9	127.6	143.0
Unconf. Press. - psi	45.6	43.1	43.2	40.9	39.9	44.6
Tare No:	1a	2a	3a	4a	5a	6a
Wt. Wet Soil + Tare	423.14	425.79	485.30	484.58	492.29	484.39
Wt. Dry Soil + Tare	350.69	353.62	412.16	412.43	418.91	411.63
Wt. Moisture	72.45	72.17	73.14	72.15	73.38	72.76
Wt. Tare	43.18	43.50	102.85	103.09	98.90	101.67
Wt. Dry Soil	307.51	310.12	309.31	309.34	310.01	309.96
Soaked Moist. Cont. %	23.5	23.3	23.7	23.6	23.7	23.5

CLAY-LIME-ASPHALT STABILIZATION

Pretreating Period	4 days	Test No.	37-42
Optimum Moisture Content (Clay-Lime Mixtures)	24.8 %	Percent Additive	10
Mix Design		Date Constructed	July 1[illegible]
Wt. Lime (5 %)	117.5 gm.	Date Broken	July [illegible]
Wt. Asphalt (5 %)	117.5 gm.	Curing Period	[illegible] days
Wt. Soil + 6 % H_2O	2500.0 gm.	Soaking Period	1 day
Wt. Water	475.0 gm.	Immersion Period	days
Moulding Moisture Content		**Results**	
Container No.	48	Aver. Dry Unit Wt. - pcf	92.9
Wt. Wet Soil + Tare	135.[illegible]6 gm.	Aver. Unconf. Load - lbs.	143.33
Wt. Dry Soil + Tare	124.27 gm.	Aver. Unconf. Press. - psi	45.0
Wt. Moisture	11.39 gm.	Aver. Soaked Moist. - %	24.2
Wt. Tare	77.53 gm.	Aver. Water Absorption - %	0.52
Wt. Dry Soil	46.7[illegible] gm.	Aver. Swelling - %	
Moisture Content	24.3 %		

Sample No:	54A37	54A38	54A39	54A40	54A41	54A42
Sample Height - inch	4.002	4.002	4.014	3.999	4.004	4.020
Wt. Wet Sample - gm.	385.2	384.2	385.5	370.[illegible]	38[illegible].[illegible]	385.3
Dry Unit Wt. - pcf	93.1	92.9	92.[illegible]	92.[illegible]	93.4	92.9
Unconf. Load - lbs.	151.[illegible]	147.4	140.8	147.4	138.6	134.2
Unconf. Press. - psi	47.6	46.1	44.0	46.1	43.5	42.0
Tare No:	1	2	3	4	5	6
Wt. Wet Soil + Tare	428.55	423.68	428.55	414.90	428.81	429.24
Wt. Dry Soil + Tare	353.57	349.28	353.50	342.69	354.16	355.01
Wt. Moisture	74.98	74.40	75.05	72.21	74.65	74.23
Wt. Tare	44.94	44.40	43.35	45.65	44.60	45.10
Wt. Dry Soil	308.93	304.88	310.15	[illegible].04	309.56	309.91
Soaked Moist. Cont. %	24.25	24.4	24.1	24.3	24.1	[illegible]

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CLAY-LIME-ASPHALT STABILIZATION

Pretreating Period 4 days

Optimum Moisture Content (Clay-Lime Mixtures) [illegible] %

Mix Design

Wt. Lime ([illegible] %) [illegible] gm.

Wt. Asphalt ([illegible] %) [illegible] gm.

Wt. Soil + [illegible] % H_2O [illegible] gm.

Wt. Water [illegible] gm.

Moulding Moisture Content

Container No. [illegible]

Wt. Wet Soil + Tare [illegible] gm.

Wt. Dry Soil + Tare [illegible] gm.

Wt. Moisture [illegible] gm.

Wt. Tare [illegible] gm.

Wt. Dry Soil [illegible] gm.

Moisture Content [illegible] %

Test No. [illegible]

Percent Additive [illegible]

Date Constructed July [illegible]

Date Broken [illegible]

Curing Period [illegible] days

Soaking Period 1 day

Immersion Period days

Results

Aver. Dry Unit Wt. - pcf [illegible]

Aver. Unconf. Load - lbs. [illegible]

Aver. Unconf. Press. - psi [illegible]

Aver. Soaked Moist. - % [illegible]

Aver. Water Absorption - % [illegible]

Aver. Swelling - % [illegible]

Sample No:	[illegible]	[illegible]	[illegible]	54A46	[illegible]	54A48
Sample Height - inch	4.012	[illegible]	[illegible]	[illegible]	[illegible]	4.010
Wt. Wet Sample - gm.	386.9	[illegible]	[illegible]	[illegible]	386.9	383.0
Dry Unit Wt. - pcf	93.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Unconf. Load - lbs.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Unconf. Press. - psi	55.8	[illegible]	[illegible]	[illegible]	50.2	[illegible]
Tare No:	1a	2a	3a	4a	5a	6a
Wt. Wet Soil + Tare	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Wt. Dry Soil + Tare	[illegible]	[illegible]	[illegible]	411.30	[illegible]	[illegible]
Wt. Moisture	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	71.41
Wt. Tare	[illegible]	[illegible]	102.85	[illegible]	[illegible]	[illegible]
Wt. Dry Soil	[illegible]	[illegible]	309.57	[illegible]	[illegible]	308.80
Soaked Moist. Cont. %	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

CLAY-LIME-ASPHALT STABILIZATION

Pretreating Period	[illegible] days	Test No.	[illegible]
Optimum Moisture Content (Clay-Lime Mixtures)	[illegible] %	Percent Additive	[illegible]
Mix Design		Date Constructed	[illegible]
Wt. Lime ([illegible] %)	[illegible] gm.	Date Broken	[illegible]
Wt. Asphalt ([illegible] %)	[illegible] gm.	Curing Period	7 days
Wt. Soil + [illegible] % H_2O	[illegible] gm.	Soaking Period	1 day
Wt. Water	[illegible] gm.	Immersion Period	days
Moulding Moisture Content		**Results**	
Container No.	[illegible]	Aver. Dry Unit Wt. - pcf	[illegible]
Wt. Wet Soil + Tare	[illegible] gm.	Aver. Unconf. Load - lbs.	[illegible]
Wt. Dry Soil + Tare	[illegible] gm.	Aver. Unconf. Press. - psi	[illegible]
Wt. Moisture	[illegible] gm.	Aver. Soaked Moist. - %	[illegible]
Wt. Tare	[illegible] gm.	Aver. Water Absorption - %	[illegible]
Wt. Dry Soil	[illegible] gm.	Aver. Swelling - %	[illegible]
Moisture Content	[illegible] %		

Sample No:	[illegible]	[illegible]	31A51	31.52	[illegible]	31A54
Sample Height - inch	[illegible]	4.052	4.090	4.083	4.081	[illegible]
Wt. Wet Sample - gm.	401.0	[illegible]	397.5	[illegible]	[illegible]	[illegible]
Dry Unit Wt. - pcf	[illegible]	[illegible]	94.3	[illegible]	[illegible]	[illegible]
Unconf. Load - lbs.	150.7	[illegible]	[illegible]	138.6	[illegible]	[illegible]
Unconf. Press. - psi	[illegible]	[illegible]	[illegible]	[illegible]	36.3	[illegible]
Tare No:	1a	2a	3a	4a	5a	6a
Wt. Wet Soil + Tare	[illegible]	[illegible]	[illegible]	[illegible]	500.15	[illegible]
Wt. Dry Soil + Tare	[illegible]	[illegible]	[illegible]	[illegible]	431.8[illegible]	[illegible]
Wt. Moisture	[illegible]	[illegible]	[illegible]	66.26	[illegible]	[illegible]
Wt. Tare	[illegible]	[illegible]	102.92	[illegible]	[illegible]	[illegible]
Wt. Dry Soil	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Soaked Moist. Cont. %	[illegible]	21.1	[illegible]	[illegible]	[illegible]	[illegible]

CLAY-LIME-ASPHALT STABILIZATION

Pretreating Period [illegible] days		Test No.	[illegible]
Optimum Moisture Content (Clay-Lime Mixtures)	[illegible] %	Percent Additive	[illegible]
Mix Design		Date Constructed	[illegible]
Wt. Lime ([illegible] %)	[illegible] gm.	Date Broken	[illegible]
Wt. Asphalt (___ %)	[illegible] gm.	Curing Period ___	days
Wt. Soil + [illegible] % H_2O	[illegible] gm.	Soaking Period [illegible]	day
Wt. Water	[illegible] gm.	Immersion Period ___	days
Moulding Moisture Content		**Results**	
Container No.	[illegible]	Aver. Dry Unit Wt. - pcf	[illegible]
Wt. Wet Soil + Tare	[illegible] gm.	Aver. Unconf. Load - lbs.	246.[illegible]
Wt. Dry Soil + Tare	[illegible] gm.	Aver. Unconf. Press. - psi	[illegible]
Wt. Moisture	[illegible] gm.	Aver. Soaked Moist. - %	[illegible]
Wt. Tare	[illegible] gm.	Aver. Water Absorption - %	[illegible]
Wt. Dry Soil	[illegible] gm.	Aver. Swelling - %	[illegible]
Moisture Content	24.[illegible] %		

Sample No:	31155	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Sample Height - inch	4.055	[illegible]	[illegible]	[illegible]	4.074	[illegible]
Wt. Wet Sample - gm.	[illegible]	327.4	[illegible]	327.5	[illegible]	[illegible]
Dry Unit Wt. - pcf	94.[illegible]	[illegible]	[illegible]	94.7	[illegible]	94.[illegible]
Unconf. Load - lbs.	[illegible]	288.[illegible]	181.5	[illegible]	[illegible]	236.[illegible]
Unconf. Press. - psi	[illegible]	33.4	[illegible]	[illegible]	[illegible]	[illegible]
Tare No:	1	2	3	4	5	6
Wt. Wet Soil + Tare	499.80	[illegible]	496.[illegible]	498.40	498.13	496.[illegible]
Wt. Dry Soil + Tare	420.36	417.[illegible]	[illegible]	420.48	[illegible]	[illegible]
Wt. Moisture	79.44	78.[illegible]	[illegible]	77.[illegible]	[illegible]	[illegible]
Wt. Tare	102.85	100.45	98.80	101.69	[illegible]	104.5[illegible]
Wt. Dry Soil	[illegible]	[illegible]	318.9[illegible]	318.79	317.61	[illegible]
Soaked Moist. Cont. %	25.0	24.[illegible]	[illegible]	24.[illegible]	[illegible]	[illegible]

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CLAY-LIME-ASPHALT STABILIZATION

Pretreating Period	2 days	Test No.	61-66
Optimum Moisture Content (Clay-Lime Mixtures)	[illegible] %	Percent Additive	9
Mix Design		Date Constructed	July [illegible]
Wt. Lime (5 %)	114.[illegible] gm.	Date Broken	July 28
Wt. Asphalt ([illegible] %)	[illegible] gm.	Curing Period	7 days
Wt. Soil + [illegible] % H_2O	[illegible] gm.	Soaking Period	1 day
Wt. Water	42.[illegible] gm.	Immersion Period	____ days
Moulding Moisture Content		**Results**	
Container No.	2	Aver. Dry Unit Wt. - pcf	94.[illegible]
Wt. Wet Soil + Tare	150.[illegible] gm.	Aver. Unconf. Load - lbs.	[illegible]3.9
Wt. Dry Soil + Tare	136.[illegible] gm.	Aver. Unconf. Press. - psi	37.7
Wt. Moisture	13.68 gm.	Aver. Soaked Moist. - %	22.75
Wt. Tare	80.30 gm.	Aver. Water Absorption - %	2.43
Wt. Dry Soil	56.[illegible] gm.	Aver. Swelling - %	2.41
Moisture Content	24.3 %		

Sample No:	32A61	32A62	32A63	32A64	32A65	32A66
Sample Height - inch	4.086	4.059	4.090	4.034	4.082	4.052
Wt. Wet Sample - gm.	397.45	39[illegible]	395.96	393.52	395.17	396.46
Dry Unit Wt. - pcf	94.4	94.7	93.[illegible]	9[illegible].3	9[illegible]	94.7
Unconf. Load - lbs.	130.8	130.9	[illegible].4	[illegible].9	1[illegible]4.3	134.2
Unconf. Press. - psi	[illegible]	40.0	34.8	33.[illegible]	37.[illegible]	41.1
Tare No:	1a	2a	3a	4a	5a	6a
Wt. Wet Soil + Tare	445.03	444.40	503.01	500.[illegible]	494.60	4[illegible]1.71
Wt. Dry Soil + Tare	370.18	369.71	428.85	426.29	421.39	4[illegible]0.35
Wt. Moisture	74.85	74.69	74.16	73.1[illegible]	73.21	71.36
Wt. Tare	43.20	43.48	102.92	103.12	98.89	101.72
Wt. Dry Soil	326.98	326.23	325.[illegible]	323.17	322.50	318.63
Soaked Moist. Cont. %	22.9	22.9	22.7	22.9	22.7	[illegible].4

CLAY-LIME-ASPHALT STABILIZATION

Pretreating Period [illegible] days

Test No. [illegible]

Optimum Moisture Content (Clay-Lime Mixtures) [illegible] %

Percent Additive 8

Mix Design

Date Constructed July [illegible]

Wt. Lime ([illegible] %) 114.5 gm.

Date Broken [illegible]

Wt. Asphalt (3 %) [illegible] gm.

Curing Period [illegible] days

Wt. Soil +8.5 % H_2O 2500.0 gm.

Soaking Period 1 day

Wt. Water [illegible].0 gm.

Immersion Period ____ days

Moulding Moisture Content

Container No. 1

Wt. Wet Soil + Tare [illegible] gm.

Wt. Dry Soil + Tare [illegible] gm.

Wt. Moisture 11.25 gm.

Wt. Tare [illegible] gm.

Wt. Dry Soil [illegible] gm.

Moisture Content 24.[illegible] %

Results

Aver. Dry Unit Wt. - pcf [illegible]

Aver. Unconf. Load - lbs. 230.5

Aver. Unconf. Press. - psi [illegible]

Aver. Soaked Moist. - % 25.3

Aver. Water Absorption - % 1.[illegible]

Aver. Swelling - % 1.4

Sample No:	32A67	32A68	32A69	32A70	32A71	32A72
Sample Height - inch	4.063	4.058	4.057	4.058	4.059	4.062
Wt. Wet Sample - gm.	395.3	[illegible]	395.[illegible]	394.8	395.5	394.0
Dry Unit Wt. - pcf	94.[illegible]	[illegible].1	[illegible]	94.2	94.[illegible]	94.0
Unconf. Load - lbs.	[illegible].8	211.6	257.4	229.9	24[illegible].0	213.4
Unconf. Press. - psi	70.[illegible]	[illegible]4.5	81.1	70.[illegible]	74.3	64.8
Tare No:	1	2	3	4	5	6
Wt. Wet Soil + Tare	440.57	439.28	[illegible].14	[illegible]1.05	440.46	439.10
Wt. Dry Soil + Tare	360.86	359.47	358.71	361.03	360.[illegible]	359.82
Wt. Moisture	79.71	79.81	80.13	80.03	[illegible].77	79.28
Wt. Tare	44.96	44.[illegible]	43.40	45.68	44.[illegible]	45.09
Wt. Dry Soil	315.[illegible]	315.[illegible]	315.31	315.34	316.0[illegible]	314.71
Soaked Moist. Cont. %	25.2	25.3	25.4	25.4	[illegible]	25.2

CLAY-LIME-ASPHALT STABILIZATION

Pretreating Period [illegible] days

Test No. [illegible]

Optimum Moisture Content (Clay-Lime Mixtures) [illegible] %

Percent Additive [illegible]

Mix Design

Date Constructed July [illegible]

Wt. Lime (5 %) 114.[illegible] gm.

Date Broken July 31

Wt. Asphalt ([illegible] %) [illegible] gm.

Curing Period 7 days

Wt. Soil + 8.5% H_2O 2500.0 gm.

Soaking Period 1 day

Wt. Water [illegible]12.0 gm.

Immersion Period ___ days

Moulding Moisture Content

Container No.	1	
Wt. Wet Soil + Tare	168.33	gm.
Wt. Dry Soil + Tare	150.96	gm.
Wt. Moisture	17.37	gm.
Wt. Tare	79.12	gm.
Wt. Dry Soil	71.84	gm.
Moisture Content	24.2	%

Results

Aver. Dry Unit Wt. - pcf	[illegible]
Aver. Unconf. Load - lbs.	114.2
Aver. Unconf. Press. - psi	34.7
Aver. Soaked Moist. - %	27.0
Aver. Water Absorption - %	2.58
Aver. Swelling - %	2.27

Sample No:	33A73	33A74	33A75	33A76	33A77	33A78
Sample Height - inch	4.052	4.044	4.052	[illegible]	4.038	4.049
Wt. Wet Sample - gm.	395.42	396.29	397.51	395.54	395.32	396.49
Dry Unit Wt. - pcf	94.4	95.1	94.9	[illegible]	95.0	95.0
Unconf. Load - lbs.	105.6	94.6	[illegible]	115.5	116.6	[illegible]
Unconf. Press. - psi	32.0	[illegible]	[illegible]3.5	35.0	35.5	38.4
Tare No:	6	2	3	4	5	1
Wt. Wet Soil + Tare	446.36	448.33	445.30	444.50	446.73	445.[illegible]
Wt. Dry Soil + Tare	360.38	362.25	360.35	360.07	361.14	361.00
Wt. Moisture	85.98	86.08	84.95	[illegible]	[illegible]	[illegible]
Wt. Tare	45.10	44.40	43.35	45.65	44.60	44.9[illegible]
Wt. Dry Soil	315.28	317.85	[illegible]17.00	314.42	316.55	316.08
Soaked Moist. Cont. %	27.3	27.1	26.8	26.9	27.1	26.9

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CLAY-LIME-ASPHALT STABILIZATION

Pretreating Period	1 days	Test No.		79-84	
Optimum Moisture Content (Clay-Lime Mixtures)	25.5 %	Percent Additive		[illegible]	
Mix Design		Date Constructed		July 23	
Wt. Lime (5 %)	[illegible] gm.	Date Broken		August [illegible]	
Wt. Asphalt (3 %)	58.6 gm.	Curing Period	28	days	
Wt. Soil +8.5 % H_2O	[illegible] gm.	Soaking Period	1	day	
Wt. Water	[illegible] gm.	Immersion Period		days	
Moulding Moisture Content		**Results**			
Container No.	[illegible]	Aver. Dry Unit Wt. - pcf		94.7	
Wt. Wet Soil + Tare	162.41 gm.	Aver. Unconf. Load - lbs.		205.8	
Wt. Dry Soil + Tare	145.48 gm.	Aver. Unconf. Press. - psi		64.0	
Wt. Moisture	16.93 gm.	Aver. Soaked Moist. - %		24.9	
Wt. Tare	75.39 gm.	Aver. Water Absorption - %		1.42	
Wt. Dry Soil	70.09 gm.	Aver. Swelling - %		1.45	
Moisture Content	24.20 %				

Sample No:	33A79	33A80	33A81	33A82	33A83	33A84
Sample Height - inch	4.046	4.060	4.048	4.060	4.048	4.050
Wt. Wet Sample - gm.	394.48	395.9	397.2	395.9	394.7	395.0
Dry Unit Wt. - pcf	94.6	94.7	95.2	94.5	94.6	94.7
Unconf. Load - lbs.	213.4	205.7	[illegible]	204.[illegible]	205.0	206.8
Unconf. Press. - psi	65.3	62.7	68.1	6[illegible].6	62.7	62.8
Tare No:	1	2	3	4	5	6
Wt. Wet Soil + Tare	438.59	440.40	440.50	44[illegible].18	439.47	439.11
Wt. Dry Soil + Tare	360.42	360.81	360.99	[illegible].46	360.59	361.70
Wt. Moisture	78.17	79.68	79.51	78.72	78.88	77.41
Wt. Tare	44.96	44.42	43.40	45.6[illegible]	44.61	45.09
Wt. Dry Soil	315.46	316.3[illegible]	[illegible].59	[illegible]	315.98	316.61
Soaked Moist. Cont. %	[illegible].8	25.2	25.1	24.9	24.9	24.5

CLAY-LIME-ASPHALT STABILIZATION

Pretreating Period ____ days		Test No.	[illegible]
Optimum Moisture Content (Clay-Lime Mixtures)	[illegible] %	Percent Additive	[illegible]
Mix Design		Date Constructed	July [illegible]
Wt. Lime ([illegible] %)	[illegible] gm.	Date Broken	[illegible]
Wt. Asphalt ([illegible] %)	[illegible] gm.	Curing Period 7	days
Wt. Soil + 8.5% H_2O	[illegible] gm.	Soaking Period 1	day
Wt. Water	41.[illegible] gm.	Immersion Period ____	days
Moulding Moisture Content		**Results**	
Container No.	2	Aver. Dry Unit Wt. - pcf	93.6
Wt. Wet Soil + Tare	16[illegible] gm.	Aver. Unconf. Load - lbs.	89.8
Wt. Dry Soil + Tare	1[illegible]8.28 gm.	Aver. Unconf. Press. - psi	27.[illegible]
Wt. Moisture	1[illegible] gm.	Aver. Soaked Moist. - %	27.6
Wt. Tare	84.48 gm.	Aver. Water Absorption - %	2.79
Wt. Dry Soil	63.80 gm.	Aver. Swelling - %	2.39
Moisture Content	5.1 %		

Sample No:	34A85	34A86	34A87	34A88	34A89	34A90
Sample Height - inch	[illegible].065	4.082	4.058	4.079	4.062	4.075
Wt. Wet Sample - gm.	396.43	395.46	395.[illegible]	395.72	39[illegible]	[illegible]95.81
Dry Unit Wt. - pcf	93.9	[illegible].4	[illegible].8	93.4	93.6	93.5
Unconf. Load - lbs.	105.6	8[illegible].6	97.9	85.0	100.[illegible]	66.0
Unconf. Press. - psi	[illegible]1.9	25.1	[illegible].5	25.7	[illegible].2	19.9
Tare No:	1	2	3	4	5	6
Wt. Wet Soil + Tare	[illegible].81	444.78	445.82	443.83	447.[illegible]5	444.22
Wt. Dry Soil + Tare	361.[illegible]	357.95	358.53	361.59	360.30	358.19
Wt. Moisture	87.41	[illegible].83	[illegible]	87.[illegible]	86.95	86.03
Wt. Tare	44.92	44.40	[illegible].35	45.65	44.60	45.10
Wt. Dry Soil	[illegible]16.48	313.55	31[illegible].18	[illegible]	[illegible]15.70	313.[illegible]
Soaked Moist. Cont. %	27.6	27.7	27.[illegible]	27.6	27.[illegible]	27.5

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CLAY-LIME-ASPHALT STABILIZATION

Pretreating Period 4 days		Test No.	91-[illegible]
Optimum Moisture Content (Clay-Lime Mixtures)	[illegible]4.8 %	Percent Additive	[illegible]
Mix Design		Date Constructed	July 24
Wt. Lime ([illegible] %)	11[illegible].[illegible] gm.	Date Broken	August 22
Wt. Asphalt (3 %)	[illegible].6 gm.	Curing Period [illegible]	days
Wt. Soil +8.5 % H_2O	2500.0 gm.	Soaking Period 1	day
Wt. Water	41[illegible].[illegible] gm.	Immersion Period ___	days
Moulding Moisture Content		**Results**	
Container No.	1	Aver. Dry Unit Wt. - pcf	[illegible]
Wt. Wet Soil + Tare	155.[illegible] gm.	Aver. Unconf. Load - lbs.	227.15
Wt. Dry Soil + Tare	140.[illegible] gm.	Aver. Unconf. Press. - psi	[illegible]3.9
Wt. Moisture	14.9[illegible] gm.	Aver. Soaked Moist. - %	25.53
Wt. Tare	80.[illegible] gm.	Aver. Water Absorption - %	1.34
Wt. Dry Soil	60.51 gm.	Aver. Swelling - %	1.[illegible]
Moisture Content	24.7 %		

Sample No:	24A91	24A92	24A93	[illegible]4	24A95	24A96
Sample Height - inch	[illegible].018	[illegible]	[illegible]	[illegible].067	4.057	4.066
Wt. Wet Sample - gm.	[illegible]	[illegible]	[illegible]	[illegible]5.1	394.2	395.1
Dry Unit Wt. - pcf	94.[illegible]	[illegible]	94.0	93.6	93.8	93.8
Unconf. Load - lbs.	[illegible]	[illegible]	[illegible]	[illegible]	203.5	[illegible]76.0
Unconf. Press. - psi	30.30	[illegible]	71.30	70.3	61.7	53.4
Tare No:	1	2	3	4	5	6
Wt. Wet Soil + Tare	[illegible]8.10	[illegible]	[illegible]	440.95	[illegible].52	439.99
Wt. Dry Soil + Tare	[illegible]	[illegible].15	[illegible]	[illegible]60.85	357.96	360.23
Wt. Moisture	[illegible]	[illegible]	[illegible]	[illegible]	80.56	79.76
Wt. Tare	44.96	44.[illegible]	[illegible]	45.68	44.61	45.09
Wt. Dry Soil	313.46	[illegible]	[illegible]	[illegible]15.17	[illegible]13.35	[illegible].14
Soaked Moist. Cont. %	[illegible]5.4	[illegible]5.6	[illegible]	25.4	[illegible].7	[illegible]

CLAY-LIME-ASPHALT STABILIZATION

Pretreating Period 1 days		Test No.	97-102
Optimum Moisture Content (Clay-Lime Mixtures)	26.7 %	Percent Additive	10
Mix Design		Date Constructed	July 25
Wt. Lime (5 %)	114.2 gm.	Date Broken	August 1
Wt. Asphalt (5 %)	114.2 gm.	Curing Period ___	days
Wt. Soil +8.7 % H_2O	2500.0 gm.	Soaking Period ___	day
Wt. Water	400.0 gm.	Immersion Period 7	days
Moulding Moisture Content		Results	
Container No.	2	Aver. Dry Unit Wt. - pcf	92.4
Wt. Wet Soil + Tare	165.02 gm.	Aver. Unconf. Load - lbs.	41.8
Wt. Dry Soil + Tare	145.49 gm.	Aver. Unconf. Press. - psi	11.9
Wt. Moisture	19.53 gm.	Aver. Soaked Moist. - %	36.8
Wt. Tare	75.41 gm.	Aver. Water Absorption - %	6.61
Wt. Dry Soil	70.08 gm.	Aver. Swelling - %	12.36
Moisture Content	27.9 %		

Sample No:	51B97	51B98	51B99	51B100	51B101	51B102
Sample Height - inch	4.040	4.036	4.030	4.042	4.032	4.038
Wt. Wet Sample - gm.	394.8	396.6	395.0	395.9	396.0	395.8
Dry Unit Wt. - pcf	92.3	92.4	92.3	92.4	92.7	92.6
Unconf. Load - lbs.	39.6	40.7	42.9	45.1	40.7	41.8
Unconf. Press. - psi	11.25	11.66	12.20	12.75	11.49	11.80
Tare No:	1a	2a	3a	4a	5a	6a
Wt. Wet Soil + Tare	458.97	463.06	521.48	523.21	520.05	521.20
Wt. Dry Soil + Tare	346.88	350.24	409.11	410.30	406.42	408.45
Wt. Moisture	112.09	112.82	112.37	112.91	113.63	112.75
Wt. Tare	43.20	43.48	102.92	103.12	98.89	101.72
Wt. Dry Soil	303.68	306.76	306.19	307.18	307.53	306.73
Soaked Moist. Cont. %	36.9	36.8	36.7	36.7	36.9	36.8

CLAY-LIME-ASPHALT STABILIZATION

Pretreating Period	1 days	Test No.	103-108
Optimum Moisture Content (Clay-Lime Mixtures)	26.7 %	Percent Additive	10
Mix Design		Date Constructed	July 25
Wt. Lime (5 %)	114.2 gm.	Date Broken	August 8
Wt. Asphalt (5 %)	114.2 gm.	Curing Period	days
Wt. Soil + 8.7 % H_2O	2500.0 gm.	Soaking Period	day
Wt. Water	400.0 gm.	Immersion Period	14 days

Moulding Moisture Content		Results	
Container No.	1	Aver. Dry Unit Wt. - pcf	92.4
Wt. Wet Soil + Tare	157.52 gm.	Aver. Unconf. Load - lbs.	35.56
Wt. Dry Soil + Tare	140.46 gm.	Aver. Unconf. Press. - psi	9.54
Wt. Moisture	17.06 gm.	Aver. Soaked Moist. - %	42.46
Wt. Tare	79.14 gm.	Aver. Water Absorption - %	10.84
Wt. Dry Soil	61.32 gm.	Aver. Swelling - %	20.57
Moisture Content	27.8 %		

Sample No:	51B103	51B104	51B105	51B106	51B107	51B108
Sample Height - inch	4.023	4.028	4.047	4.038	4.031	4.036
Wt. Wet Sample - gm.	395.1	395.5	395.4	396.5	395.8	395.4
Dry Unit Wt. - pcf	92.6	92.6	92.2	92.6	92.4	92.3
Unconf. Load - lbs.	37.4	36.3	35.2	37.4	35.2	31.9
Unconf. Press. - psi	10.03	9.71	9.48	10.03	9.43	8.55
Tare No:	1a	2a	3a	4a	5a	6a
Wt. Wet Soil + Tare	478.79	479.35	528.27	538.37	537.45	534.05
Wt. Dry Soil + Tare	348.22	349.22	400.98	408.78	404.40	407.45
Wt. Moisture	130.57	130.13	127.29	129.59	133.05	126.60
Wt. Tare	43.18	43.50	102.85	103.09	98.90	101.67
Wt. Dry Soil	305.04	305.72	298.13	305.69	305.50	305.78
Soaked Moist. Cont. %	42.8	42.4	42.7	42.4	43.0	41.3

CLAY-LIME-ASPHALT STABILIZATION

Pretreating Period	2 days	Test No.	109-114
Optimum Moisture Content (Clay-Lime Mixtures)	20.6 %	Percent Additive	10
Mix Design		Date Constructed	July 26
Wt. Lime (5 %)	114.2 gm.	Date Broken	August 2
Wt. Asphalt (5 %)	114.2 gm.	Curing Period ___	days
Wt. Soil +8.7 % H_2O	2500.0 gm.	Soaking Period ___	day
Wt. Water	400.0 gm.	Immersion Period 7	days
Moulding Moisture Content		Results	
Container No.	2	Aver. Dry Unit Wt. - pcf	94.3
Wt. Wet Soil + Tare	169.78 gm.	Aver. Unconf. Load - lbs.	39.0
Wt. Dry Soil + Tare	152.20 gm.	Aver. Unconf. Press. - psi	10.99
Wt. Moisture	17.58 gm.	Aver. Soaked Moist. - %	35.3
Wt. Tare	84.50 gm.	Aver. Water Absorption - %	6.66
Wt. Dry Soil	67.70 gm.	Aver. Swelling - %	12.70
Moisture Content	25.9 %		

Sample No:	52B109	52B110	52B111	52B112	52B113	52B114
Sample Height - inch	4.035	4.020	4.043	4.022	4.032	4.047
Wt. Wet Sample - gm.	397.5	397.0	398.0	395.6	396.5	396.8
Dry Unit Wt. - pcf	94.4	94.7	94.3	94.3	94.2	94.0
Unconf. Load - lbs.	39.6	36.3	36.3	44.0	39.6	38.3
Unconf. Press. - psi	11.19	10.13	10.30	12.40	11.12	10.82
Tare No:	1	2	3	4	5	6
Wt. Wet Soil + Tare	466.48	465.52	465.23	464.61	464.19	465.62
Wt. Dry Soil + Tare	356.40	355.93	355.44	355.50	354.61	355.83
Wt. Moisture	110.08	109.59	109.79	109.11	109.58	109.79
Wt. Tare	44.92	44.40	43.35	45.65	44.60	45.10
Wt. Dry Soil	311.48	311.53	312.09	309.85	310.01	310.73
Soaked Moist. Cont. %	35.4	35.2	35.2	35.3	35.3	35.3

CLAY-LIME-ASPHALT STABILIZATION

Pretreating Period	2 days	Test No.	115-120
Optimum Moisture Content (Clay-Lime Mixtures)	26.6 %	Percent Additive	10
Mix Design		Date Constructed	July 26
Wt. Lime (5 %)	114.2 gm.	Date Broken	August 9
Wt. Asphalt (5 %)	114.2 gm.	Curing Period	___ days
Wt. Soil +8.7 % H_2O	2500.0 gm.	Soaking Period	14 day
Wt. Water	400.0 gm.	Immersion Period	14 days
Moulding Moisture Content		Results	
Container No.	1	Aver. Dry Unit Wt. - pcf	94.3
Wt. Wet Soil + Tare	163.98 gm.	Aver. Unconf. Load - lbs.	29.7
Wt. Dry Soil + Tare	146.92 gm.	Aver. Unconf. Press. - psi	8.0
Wt. Moisture	17.06 gm.	Aver. Soaked Moist. - %	41.3
Wt. Tare	80.31 gm.	Aver. Water Absorption - %	10.83
Wt. Dry Soil	66.61 gm.	Aver. Swelling - %	19.60
Moisture Content	25.6 %		

Sample No:	52B115	52B116	52B117	52B118	52B119	52B120
Sample Height - inch	4.035	4.025	4.043	4.031	4.041	4.042
Wt. Wet Sample - gm.	396.4	396.1	396.7	396.5	397.3	393.3
Dry Unit Wt. - pcf	94.2	94.4	94.2	94.3	94.2	94.2
Unconf. Load - lbs.	31.9	28.6	30.8	28.6	27.5	30.8
Unconf. Press. - psi	8.63	7.71	8.32	7.73	7.42	8.23
Tare No:	1a	2a	3a	4a	5a	6a
Wt. Wet Soil + Tare	479.70	480.04	540.98	540.17	536.77	539.11
Wt. Dry Soil + Tare	352.37	351.97	411.84	412.23	408.80	411.99
Wt. Moisture	127.33	128.07	129.24	127.94	127.97	127.12
Wt. Tare	43.18	43.50	102.85	103.09	100.10	101.67
Wt. Dry Soil	309.19	308.47	308.99	309.14	309.90	310.32
Soaked Moist. Cont. %	41.2	41.5	41.5	41.4	41.3	41.0

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CLAY-LIME-ASPHALT STABILIZATION

Pretreating Period	3 days	Test No.	121-126
Optimum Moisture Content (Clay-Lime Mixtures)	25.5 %	Percent Additive	10
Mix Design		Date Constructed	July 27
Wt. Lime (5 %)	114.2 gm.	Date Broken	August 3
Wt. Asphalt (5 %)	114.2 gm.	Curing Period	days
Wt. Soil + 8.7% H_2O	2500.0 gm.	Soaking Period	day
Wt. Water	400.0 gm.	Immersion Period	7 days
Moulding Moisture Content		**Results**	
Container No.	1	Aver. Dry Unit Wt. - pcf	93.2
Wt. Wet Soil + Tare	158.95 gm.	Aver. Unconf. Load - lbs.	42.7
Wt. Dry Soil + Tare	142.57 gm.	Aver. Unconf. Press. - psi	12.0
Wt. Moisture	16.38 gm.	Aver. Soaked Moist. - %	36.2
Wt. Tare	80.31 gm.	Aver. Water Absorption - %	6.10
Wt. Dry Soil	62.26 gm.	Aver. Swelling - %	12.35
Moisture Content	26.3 %		

Sample No:	53B121	53B122	53B123	53B124	53B125	53B126
Sample Height - inch	4.017	4.033	4.038	4.042	4.038	4.008
Wt. Wet Sample - gm.	393.5	394.7	394.4	394.2	393.9	392.0
Dry Unit Wt. - pcf	93.3	93.3	93.2	93.2	93.1	93.2
Unconf. Load - lbs.	39.6	39.6	40.7	39.6	47.3	49.5
Unconf. Press. - psi	11.19	11.15	11.49	11.22	13.35	13.89
Tare No:	1a	2a	3a	4a	5a	6a
Wt. Wet Soil + Tare	459.86	460.49	519.61	491.90	514.88	514.78
Wt. Dry Soil + Tare	349.34	349.64	409.37	388.58	405.00	403.63
Wt. Moisture	110.56	110.85	110.24	103.42	109.88	111.15
Wt. Tare	43.18	43.50	102.85	103.09	109.88	101.67
Wt. Dry Soil	306.16	306.14	306.52	285.49	306.10	301.96
Soaked Moist. Cont. %	36.1	36.2	36.0	36.2	35.9	36.8

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CLAY-LIME-ASPHALT STABILIZATION

Pretreating Period 3 days		Test No.	127-132
Optimum Moisture Content (Clay-Lime Mixtures)	25.5 %	Percent Additive	10
Mix Design		Date Constructed	July 27
Wt. Lime (5 %)	114.5 gm.	Date Broken	August 10
Wt. Asphalt (5 %)	114.5 gm.	Curing Period ___	days
Wt. Soil +8.7 % H_2O	2500.0 gm.	Soaking Period ___	day
Wt. Water	400.0 gm.	Immersion Period 14	days
Moulding Moisture Content		**Results**	
Container No.	3	Aver. Dry Unit Wt. - pcf	93.2
Wt. Wet Soil + Tare	157.85 gm.	Aver. Unconf. Load - lbs.	31.7
Wt. Dry Soil + Tare	141.15 gm.	Aver. Unconf. Press. - psi	8.56
Wt. Moisture	16.70 gm.	Aver. Soaked Moist. - %	41.23
Wt. Tare	77.44 gm.	Aver. Water Absorption - %	9.99
Wt. Dry Soil	63.71 gm.	Aver. Swelling - %	18.99
Moisture Content	26.2 %		

Sample No:	53N127	53B128	53B129	53B130	53B131	53B132
Sample Height - inch	4.024	4.044	4.032	4.025	4.029	4.044
Wt. Wet Sample - gm.	394.1	395.0	394.0	394.1	393.4	394.5
Dry Unit Wt. - pcf	93.4	93.3	93.2	93.3	93.1	93.2
Unconf. Load - lbs.	35.2	31.9	31.9	29.7	33.0	28.6
Unconf. Press. - psi	9.50	8.63	8.59	8.02	8.90	7.72
Tare No:	1	2	3	4	5	6
Wt. Wet Soil + Tare	475.52	476.07	474.26	476.61	474.39	475.60
Wt. Dry Soil + Tare	349.60	349.99	348.09	351.23	349.00	351.05
Wt. Moisture	125.92	127.08	127.17	125.38	125.39	124.55
Wt. Tare	44.95	44.41	43.39	45.68	44.60	45.09
Wt. Dry Soil	304.65	305.58	304.70	305.55	304.40	305.96
Soaked Moist. Cont. %	41.3	41.6	41.4	41.1	41.2	40.8

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CLAY-LIME-ASPHALT STABILIZATION

Pretreating Period 4 days		Test No.		133-138
Optimum Moisture Content (Clay-Lime Mixtures)	24.8 %	Percent Additive		10
Mix Design		Date Constructed		July 28
Wt. Lime (5 %)	114.2 gm.	Date Broken		August 4
Wt. Asphalt (5 %)	114.2 gm.	Curing Period	___	days
Wt. Soil +8.7 % H_2O	2500.0 gm.	Soaking Period	___	day
Wt. Water	400.0 gm.	Immersion Period	7	days
Moulding Moisture Content		Results		
Container No.	2	Aver. Dry Unit Wt. - pcf		93.9
Wt. Wet Soil + Tare	160.20 gm.	Aver. Unconf. Load - lbs.		36.1
Wt. Dry Soil + Tare	143.24 gm.	Aver. Unconf. Press. - psi		10.13
Wt. Moisture	16.76 gm.	Aver. Soaked Moist. - %		35.3
Wt. Tare	79.13 gm.	Aver. Water Absorption - %		7.21
Wt. Dry Soil	64.11 gm.	Aver. Swelling - %		13.33
Moisture Content	26.1 %			

Sample No:	54B133	54B134	54B135	54B136	54B137	54B138
Sample Height - inch	4.043	4.042	4.041	4.035	4.041	4.044
Wt. Wet Sample - gm.	396.0	397.3	397.3	397.0	396.3	396.2
Dry Unit Wt. - pcf	93.9	94.1	94.1	94.0	93.9	93.7
Unconf. Load - lbs.	33.0	36.3	36.3	36.3	35.2	39.6
Unconf. Press. - psi	9.40	10.13	10.13	10.15	9.89	11.11
Tare No:	1	2	3	4	5	6
Wt. Wet Soil + Tare	467.92	467.70	468.95	469.95	466.08	466.50
Wt. Dry Soil + Tare	357.49	357.65	358.27	358.08	356.19	357.22
Wt. Moisture	110.43	110.05	110.68	111.87	109.89	109.28
Wt. Tare	44.95	44.41	43.35	45.68	44.62	45.09
Wt. Dry Soil	312.54	313.24	314.88	312.40	311.57	312.13
Soaked Moist. Cont. %	35.3	35.3	35.2	35.5	35.3	35.0

CLAY-LIME-ASPHALT STABILIZATION

Pretreating Period 4 days		Test No.	139-144
Optimum Moisture Content (Clay-Lime Mixtures)	24.8 %	Percent Additive	10
Mix Design		Date Constructed	July 28
Wt. Lime (5 %)	114.2 gm.	Date Broken	August 11
Wt. Asphalt (5 %)	114.2 gm.	Curing Period ____	days
Wt. Soil +8.7 % H_2O	2500.0 gm.	Soaking Period ____	day
Wt. Water	400.0 gm.	Immersion Period 14	days
Moulding Moisture Content		**Results**	
Container No.	2	Aver. Dry Unit Wt. - pcf	94.0
Wt. Wet Soil + Tare	160.20 gm.	Aver. Unconf. Load - lbs.	25.85
Wt. Dry Soil + Tare	142.81 gm.	Aver. Unconf. Press. - psi	7.0
Wt. Moisture	17.39 gm.	Aver. Soaked Moist. - %	39.6
Wt. Tare	75.40 gm.	Aver. Water Absorption - %	10.89
Wt. Dry Soil	67.41 gm.	Aver. Swelling - %	19.04
Moisture Content	25.8 %		

Sample No:	54B139	54B140	54B141	54B142	54B143	54B144
Sample Height - inch	4.038	4.035	4.044	4.041	4.040	4.049
Wt. Wet Sample - gm.	396.6	396.3	396.8	396.7	396.8	396.6
Dry Unit Wt. - pcf	94.0	94.0	94.0	94.1	94.1	93.9
Unconf. Load - lbs.	26.4	27.5	25.3	24.2	26.4	25.3
Unconf. Press. - psi	7.16	7.45	6.83	6.57	7.15	6.86
Tare No:	1	2	3	4	5	6
Wt. Wet Soil + Tare	481.09	480.11	479.59	481.80	480.10	480.87
Wt. Dry Soil + Tare	356.91	356.39	355.86	358.29	357.38	356.93
Wt. Moisture	124.18	123.72	123.73	123.51	122.72	123.94
Wt. Tare	44.95	44.41	43.39	45.68	44.60	45.09
Wt. Dry Soil	311.96	311.98	312.47	312.61	312.78	311.84
Soaked Moist. Cont. %	39.9	39.7	39.1	39.5	39.3	39.7

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CLAY-LIME-ASPHALT STABILIZATION

Pretreating Period	1 days	Test No.	145-150
Optimum Moisture Content (Clay-Lime Mixtures)	26.7 %	Percent Additive	8
Mix Design		Date Constructed	July 31
Wt. Lime (5 %)	115.0 gm.	Date Broken	August 7
Wt. Asphalt (3 %)	69.0 gm.	Curing Period ____	days
Wt. Soil + 8 % H_2O	2500.0 gm.	Soaking Period ____	day
Wt. Water	416.0 gm.	Immersion Period 7	days
Moulding Moisture Content		**Results**	
Container No.	2	Aver. Dry Unit Wt. - pcf	95.2
Wt. Wet Soil + Tare	169.82 gm.	Aver. Unconf. Load - lbs.	53.53
Wt. Dry Soil + Tare	152.30 gm.	Aver. Unconf. Press. - psi	15.17
Wt. Moisture	17.52 gm.	Aver. Soaked Moist. - %	35.5
Wt. Tare	84.50 gm.	Aver. Water Absorption - %	6.80
Wt. Dry Soil	67.80 gm.	Aver. Swelling - %	13.64
Moisture Content	25.9 %		

Sample No:	31B145	31B146	31B147	31B148	31B149	31B150
Sample Height - inch	4.031	4.024	4.037	4.027	4.025	4.028
Wt. Wet Sample - gm.	401.8	399.4	401.2	399.5	399.7	401.0
Dry Unit Wt. - pcf	95.6	95.1	95.4	94.9	95.0	95.3
Unconf. Load - lbs.	49.5	56.1	51.7	50.6	58.3	55.0
Unconf. Press. - psi	14.11	15.92	14.15	14.35	16.48	15.60
Tare No:	1	2	3	4	5	6
Wt. Wet Soil + Tare	471.68	468.68	470.89	469.15	470.40	470.28
Wt. Dry Soil + Tare	360.37	358.12	358.51	357.58	359.65	358.97
Wt. Moisture	111.31	110.56	112.38	111.57	110.75	111.31
Wt. Tare	44.95	44.41	43.39	44.62	45.09	45.68
Wt. Dry Soil	315.42	313.71	315.12	313.29	314.56	312.96
Soaked Moist. Cont. %	35.3	35.3	35.7	35.7	35.3	35.6

CLAY-LIME-ASPHALT STABILIZATION

Pretreating Period	1 days	Test No.	151-156
Optimum Moisture Content (Clay-Lime Mixtures)	26.7 %	Percent Additive	8
Mix Design		Date Constructed	July 31
Wt. Lime (5 %)	115.0 gm.	Date Broken	August 14
Wt. Asphalt (3 %)	69.0 gm.	Curing Period ___	days
Wt. Soil + 8 % H_2O	2500.0 gm.	Soaking Period ___	day
Wt. Water	416.0 gm.	Immersion Period 14	days
Moulding Moisture Content		**Results**	
Container No.	1	Aver. Dry Unit Wt. - pcf	94.9
Wt. Wet Soil + Tare	175.79 gm.	Aver. Unconf. Load - lbs.	55.2
Wt. Dry Soil + Tare	156.20 gm.	Aver. Unconf. Press. - psi	15.49
Wt. Moisture	19.59 gm.	Aver. Soaked Moist. - %	36.5
Wt. Tare	80.30 gm.	Aver. Water Absorption - %	8.12
Wt. Dry Soil	75.90 gm.	Aver. Swelling - %	15.48
Moisture Content	25.8 %		

Sample No:	31B151	31B152	31B153	31B154	31B155	31B156
Sample Height - inch	4.037	4.043	4.043	4.043	4.027	4.050
Wt. Wet Sample - gm.	400.3	402.1	399.1	400.3	398.4	398.3
Dry Unit Wt. - pcf	95.2	95.5	94.8	94.8	94.7	94.3
Unconf. Load - lbs.	58.3	60.5	50.6	55.0	53.9	52.8
Unconf. Press. - psi	16.45	16.95	14.18	15.42	15.12	14.83
Tare No:	1	2	3	4	5	6
Wt. Wet Soil + Tare	474.28	474.45	472.55	475.24	471.61	472.08
Wt. Dry Soil + Tare	358.13	359.08	361.05	359.75	356.87	358.44
Wt. Moisture	116.15	115.37	111.50	115.49	114.74	113.64
Wt. Tare	44.96	44.42	43.40	45.68	44.61	45.09
Wt. Dry Soil	313.17	314.66	317.65	314.07	312.26	313.35
Soaked Moist. Cont. %	37.1	36.7	35.1	36.7	36.7	36.3

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CLAY-LIME-ASPHALT STABILIZATION

Pretreating Period	2 days	Test No.		157-162
Optimum Moisture Content (Clay-Lime Mixtures)	26.6 %	Percent Additive		8
Mix Design		Date Constructed		August 1
Wt. Lime (5 %)	115.0 gm.	Date Broken		August 8
Wt. Asphalt (3 %)	69.0 gm.	Curing Period	___	days
Wt. Soil + 8 % H_2O	2500.0 gm.	Soaking Period	___	day
Wt. Water	416.0 gm.	Immersion Period	7	days
Moulding Moisture Content		**Results**		
Container No.	1	Aver. Dry Unit Wt. - pcf		95.8
Wt. Wet Soil + Tare	177.16 gm.	Aver. Unconf. Load - lbs.		46.2
Wt. Dry Soil + Tare	159.34 gm.	Aver. Unconf. Press. - psi		13.09
Wt. Moisture	17.82 gm.	Aver. Soaked Moist. - %		35.15
Wt. Tare	87.10 gm.	Aver. Water Absorption - %		6.38
Wt. Dry Soil	72.24 gm.	Aver. Swelling - %		12.09
Moisture Content	24.7 %			

Sample No:	32B157	32B158	32B159	32B160	32B161	32B162
Sample Height - inch	4.041	4.036	4.030	4.035	4.035	4.031
Wt. Wet Sample - gm.	399.5	401.5	398.4	400.8	400.3	399.8
Dry Unit Wt. - pcf	95.6	96.2	95.4	95.9	95.9	95.7
Unconf. Load - lbs.	49.5	49.3	47.3	44.0	47.3	41.8
Unconf. Press. - psi	14.02	13.45	13.42	12.48	13.38	11.79
Tare No:	1	2	3	4	5	6
Wt. Wet Soil + Tare	467.91	468.50	469.54	468.59	468.56	465.72
Wt. Dry Soil + Tare	357.89	358.28	258.87	258.44	358.71	355.96
Wt. Moisture	110.02	110.22	110.67	110.15	109.85	109.76
Wt. Tare	44.95	43.41	45.65	44.62	45.09	43.39
Wt. Dry Soil	312.94	314.87	312.57	313.19	313.82	312.57
Soaked Moist. Cont. %	35.2	35.0	35.1	35.2	35.2	35.1

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CLAY-LIME-ASPHALT STABILIZATION

Pretreating Period	2 days	Test No.	163-168
Optimum Moisture Content (Clay-Lime Mixtures)	26.6 %	Percent Additive	8
Mix Design		Date Constructed	August 1
Wt. Lime (5 %)	115.0 gm.	Date Broken	August 15
Wt. Asphalt (3 %)	69.0 gm.	Curing Period	___ days
Wt. Soil + 8 % H_2O	2500.0 gm.	Soaking Period	___ day
Wt. Water	416.0 gm.	Immersion Period	14 days
Moulding Moisture Content		Results	
Container No.	2	Aver. Dry Unit Wt. - pcf	96.0
Wt. Wet Soil + Tare	180.45 gm.	Aver. Unconf. Load - lbs.	49.86
Wt. Dry Soil + Tare	161.69 gm.	Aver. Unconf. Press. - psi	13.84
Wt. Moisture	18.76 gm.	Aver. Soaked Moist. - %	37.4
Wt. Tare	84.85 gm.	Aver. Water Absorption - %	8.48
Wt. Dry Soil	76.84 gm.	Aver. Swelling - %	15.64
Moisture Content	24.5 %		

Sample No:	32B163	32B164	32B165	32B166	32B167	32B168
Sample Height - inch	4.029	4.036	4.025	4.025	4.032	4.021
Wt. Wet Sample - gm.	399.8	400.0	400.0	400.0	399.7	399.6
Dry Unit Wt. - pcf	95.9	95.9	96.1	96.1	95.9	96.2
Unconf. Load - lbs.	52.8	51.7	51.7	46.2	47.3	49.5
Unconf. Press. - psi	14.62	14.36	14.29	12.85	13.19	13.76
Tare No:	1	2	3	4	5	6
Wt. Wet Soil + Tare	476.61	475.67	476.94	474.92	475.47	475.59
Wt. Dry Soil + Tare	358.37	358.06	359.85	357.41	358.98	358.60
Wt. Moisture	118.24	117.61	117.09	117.51	116.49	116.99
Wt. Tare	45.09	45.68	44.61	43.40	44.42	44.96
Wt. Dry Soil	313.28	312.38	315.24	314.01	314.56	313.64
Soaked Moist. Cont. %	37.7	37.7	37.2	37.4	37.1	37.3

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CLAY-LIME-ASPHALT STABILIZATION

Pretreating Period 3 days			Test No.		169-174
Optimum Moisture Content (Clay-Lime Mixtures)	25.5 %		Percent Additive		8
Mix Design			Date Constructed		August 2
Wt. Lime (5 %)	115.0	gm.	Date Broken		August 9
Wt. Asphalt (3 %)	69.0	gm.	Curing Period	___	days
Wt. Soil + 8 % H_2O	2500.0	gm.	Soaking Period	___	day
Wt. Water	416.0	gm.	Immersion Period	7	days
Moulding Moisture Content			**Results**		
Container No.	2		Aver. Dry Unit Wt. - pcf		94.1
Wt. Wet Soil + Tare	159.38	gm.	Aver. Unconf. Load - lbs.		42.9
Wt. Dry Soil + Tare	143.68	gm.	Aver. Unconf. Press. - psi		12.39
Wt. Moisture	15.70	gm.	Aver. Soaked Moist. - %		35.46
Wt. Tare	84.50	gm.	Aver. Water Absorption - %		6.49
Wt. Dry Soil	59.18	gm.	Aver. Swelling - %		12.94
Moisture Content	26.5	%			

Sample No:	32B169	33B170	33B171	33B172	33B173	33B174
Sample Height - inch	4.020	4.024	4.014	4.028	4.017	4.023
Wt. Wet Sample - gm.	399.0	396.9	396.7	399.0	398.1	398.5
Dry Unit Wt. - pcf	94.4	93.8	93.9	94.2	94.3	94.2
Unconf. Load - lbs.	42.9	35.2	47.3	44.0	42.9	45.1
Unconf. Press. - psi	12.23	9.98	13.51	12.60	12.20	12.81
Tare No:	1	2	3	4	5	6
Wt. Wet Soil + Tare	467.30	464.45	463.42	467.88	466.10	466.98
Wt. Dry Soil + Tare	357.04	354.16	353.59	357.47	356.01	357.13
Wt. Moisture	110.26	110.29	109.83	110.41	110.09	109.85
Wt. Tare	44.95	44.41	43.39	45.68	44.60	45.09
Wt. Dry Soil	312.09	309.15	310.20	311.79	311.41	312.04
Soaked Moist. Cont. %	35.4	35.9	35.4	35.5	35.4	35.2

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CLAY-LIME-ASPHALT STABILIZATION

Pretreating Period	3 days	Test No.		175-180
Optimum Moisture Content (Clay-Lime Mixtures)	25.5 %	Percent Additive		8
Mix Design		Date Constructed		August 2
Wt. Lime (5 %)	115.0 gm.	Date Broken		August 16
Wt. Asphalt (3 %)	69.0 gm.	Curing Period	___	days
Wt. Soil + 8 % H_2O	2500.0 gm.	Soaking Period	___	day
Wt. Water	416.0 gm.	Immersion Period	14	days

Moulding Moisture Content		Results	
Container No.	1	Aver. Dry Unit Wt. - pcf	94.0
Wt. Wet Soil + Tare	164.13 gm.	Aver. Unconf. Load - lbs.	36.1
Wt. Dry Soil + Tare	146.71 gm.	Aver. Unconf. Press. - psi	9.99
Wt. Moisture	17.42 gm.	Aver. Soaked Moist. - %	38.5
Wt. Tare	80.30 gm.	Aver. Water Absorption - %	9.21
Wt. Dry Soil	66.41 gm.	Aver. Swelling - %	16.03
Moisture Content	26.3 %		

Sample No:	33B175	33B176	33B177	33B178	33B179	33B180
Sample Height - inch	4.023	4.038	4.046	4.043	4.031	4.038
Wt. Wet Sample - gm.	399.0	396.9	396.7	399.0	398.1	398.5
Dry Unit Wt. - pcf	94.4	93.7	93.5	94.1	94.0	94.0
Unconf. Load - lbs.	42.9	44.0	37.4	30.8	30.8	30.8
Unconf. Press. - psi	11.96	12.12	10.39	8.48	8.53	8.50
Tare No:	1	2	3	4	5	6
Wt. Wet Soil + Tare	475.49	476.31	462.08	478.49	474.56	476.43
Wt. Dry Soil + Tare	354.35	355.59	344.92	358.60	354.99	356.98
Wt. Moisture	121.14	120.72	117.16	119.89	119.57	119.45
Wt. Tare	44.96	44.42	43.40	45.68	44.61	45.09
Wt. Dry Soil	309.39	311.17	301.52	312.92	310.38	311.87
Soaked Moist. Cont. %	39.2	38.8	38.9	37.3	38.5	38.3

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CLAY-LIME-ASPHALT STABILIZATION

Pretreating Period	4	days	Test No.		181-186
Optimum Moisture Content (Clay-Lime Mixtures)	24.8	%	Percent Additive		8
Mix Design			Date Constructed		August 3
Wt. Lime (5 %)	115.0	gm.	Date Broken		August 10
Wt. Asphalt (3 %)	69.0	gm.	Curing Period		days
Wt. Soil + 8 % H_2O	2500.0	gm.	Soaking Period		day
Wt. Water	416.0	gm.	Immersion Period	7	days
Moulding Moisture Content			**Results**		
Container No.	1		Aver. Dry Unit Wt. - pcf		93.5
Wt. Wet Soil + Tare	~~183.61~~	gm.	Aver. Unconf. Load - lbs.		33.73
Wt. Dry Soil + Tare	163.76	gm.	Aver. Unconf. Press. - psi		9.57
Wt. Moisture	19.85	gm.	Aver. Soaked Moist. - %		34.95
Wt. Tare	87.14	gm.	Aver. Water Absorption - %		7.69
Wt. Dry Soil	76.62	gm.	Aver. Swelling - %		12.37
Moisture Content	25.9	%			

Sample No:	34B181	34B182	34B183	34B184	34B185	34B186
Sample Height - inch	4.042	4.052	4.030	4.032	4.033	4.012
Wt. Wet Sample - gm.	395.0	396.2	396.4	393.2	393.1	391.3
Dry Unit Wt. - pcf	93.6	93.4	94.2	93.3	93.3	93.3
Unconf. Load - lbs.	26.4	33.0	37.4	35.2	34.1	36.3
Unconf. Press. - psi	7.50	9.34	10.60	9.98	9.68	10.30
Tare No:	1a	2a	3a	4a	5a	6a
Wt. Wet Soil + Tare	524.56	522.65	534.69	641.87	670.52	637.97
Wt. Dry Soil + Tare	415.20	415.80	425.69	528.82	562.41	529.50
Wt. Moisture	109.36	106.85	109.00	113.05	108.11	108.47
Wt. Tare	100.49	104.91	110.64	218.60	249.90	220.36
Wt. Dry Soil	314.71	310.89	315.05	310.22	312.51	309.14
Soaked Moist. Cont. %	34.8	34.5	34.6	36.4	34.5	34.5

CLAY-LIME-ASPHALT STABILIZATION

Pretreating Period	4 days	Test No.	193-198
Optimum Moisture Content (Clay-Lime Mixtures)	24.8 %	Percent Additive	8
Mix Design		Date Constructed	August 11
Wt. Lime (5 %)	115.0 gm.	Date Broken	August 25
Wt. Asphalt (3 %)	69.0 gm.	Curing Period	___ days
Wt. Soil + 8% H_2O	2500.0 gm.	Soaking Period	___ day
Wt. Water	416.0 gm.	Immersion Period	14 days
Moulding Moisture Content		**Results**	
Container No.	2	Aver. Dry Unit Wt. - pcf	93.2
Wt. Wet Soil + Tare	178.49 gm.	Aver. Unconf. Load - lbs.	30.2
Wt. Dry Soil + Tare	159.28 gm.	Aver. Unconf. Press. - psi	8.67
Wt. Moisture	19.21 gm.	Aver. Soaked Moist. - %	40.3
Wt. Tare	84.90 gm.	Aver. Water Absorption - %	9.39
Wt. Dry Soil	74.38 gm.	Aver. Swelling - %	18.7
Moisture Content	25.9 %		

Sample No:	34B193	34B194	34B195	34B196	34B197	34B198
Sample Height - inch	4.043	4.050	4.048	4.049	4.042	4.040
Wt. Wet Sample - gm.	394.20	394.10	394.40	393.20	393.0	393.20
Dry Unit Wt. - pcf	93.4	93.2	93.3	93.0	93.1	93.2
Unconf. Load - lbs.	28.6	26.4	34.1	34.1	30.8	27.5
Unconf. Press. - psi	8.19	7.57	9.79	9.78	8.83	7.90
Tare No:	1	2	3	4	5	6
Wt. Wet Soil + Tare	476.27	476.39	475.53	479.24	476.87	477.37
Wt. Dry Soil + Tare	352.85	353.17	351.29	352.69	353.11	352.97
Wt. Moisture	123.42	123.22	124.34	124.55	123.76	124.40
Wt. Tare	44.96	44.42	43.40	45.68	44.61	45.09
Wt. Dry Soil	307.89	308.75	309.89	307.01	308.50	307.88
Soaked Moist. Cont. %	40.2	39.9	40.4	40.7	40.2	40.4